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A COMPARATIVE STUDY OF THE QUALITY OF VIRGINIA TOBACCO PRODUCED IN THE PHILIPPINES

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ONE TEXT FIGURE

The production of cigarette leaf tobacco is already an established industry in the Philippines, considering the area devoted to it, which is estimated to be about 270 hectares for the 1935–1936 tobacco season. There are three varieties of tobacco of the Virginia type which are now grown extensively in the Philippines, each producing a normal crop of from 15 to 20 quintals per hectare. These varieties are the North Carolina Bright Yellow, Adcock, and Orinoco. Considering the price paid for this type of tobacco in the local market, which ranges from ₱12 to ₱22 per quintal, the present average production per hectare is already very satisfactory.

As a general rule, the quality of cigarette tobacco is greatly influenced by the soil and climate in the locality where it is grown.

OBJECTS OF INVESTIGATION

The present investigation has for its objects, first, to compare the qualities of cigarette leaf tobacco produced in different locali-

ties of the Philippines; and second, to find out the difference in quality between the locally produced Virginia tobacco and the imported product.

TIME AND PLACE OF INVESTIGATION

These studies were undertaken from September, 1933, to November, 1935. The field investigations were conducted in four localities: (1) Maligaya Rice Station, Muñoz, Nueva Ecija; (2) Hacienda Esperanza, Rosales, Pangasinan; (3) Dingras, Ilocos Norte; and (4) Angeles, Pampanga. The laboratory studies were conducted at the Tobacco Research Section, Bureau of Plant Industry, Manila.

REVIEW OF LITERATURE

Soil and climate.—Paguirigan(35) reports that any slight variation in soil and climatic conditions affects the tobacco plant. He states that even taking a single municipality in Isabela Province, variations in the quality of the tobacco product among the different barrios, notwithstanding identical time and methods of planting, are to be noted. Clark(9) claims that the tobacco plant exhibits a wide range of adaptability with respect to climate. However, the tobacco plant is very sensitive to sharp temperature changes between day and night. Moss and his associates(27) pointed out that the ideal growing season for flue-cured tobacco is one in which the rainfall is sufficient for the plant to make rapid and uninterrupted growth from the time of transplanting until maturity. Heavy rains on the lighter soil types, especially during the early part of the growing season, either wash away or leach out a considerable quantity of the soluble plant food elements, causing the plant to make a rather poor growth and show a lack of green color. During extremely dry seasons, however, there might be insufficient moisture to dissolve the plant food, and this of course, reduces yield and quality. Bailey and Anderson(6) in their studies on the burning qualities of tobacco found out that the poor burning crop was grown in an extremely dry season (1924) and the good burning crop during a season of high rainfall (1927).

Moss(30) claims that light soils of sandy or a sandy loam character are best adapted to the growth of bright tobacco, producing leaves with bright color, good aroma, and low in nitrogenous constituents. The average mechanical analysis of the

surface soil of typical flue-cured tobacco soils in the United States are as follows:

Soil type	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
	Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
Gransville coarse sandy loam	15.3	23.9	10.4	14.5	8.1	19.2	8.0
Durham coarse sandy loam	12.9	18.1	12.4	23.2	8.2	19.2	5.8
Cecil sandy loam	5.3	16.7	10.2	24.2	11.2	23.6	8.5
Norfolk sandy loam	2.5	17.3	15.4	19.0	6.3	29.5	9.8

Chemical analysis shows that on the average these soils are very poor in plant nutrients, particularly nitrogen, phosphorous, calcium, and magnesium. The average of the plant food constituents per acre for $6\frac{2}{3}$ inches of surface soil of the four major bright tobacco soils are as follows:

	Nitrogen	Phosphoric acid	Potash	Lime (CaO)	Magnesia (MgO)
	lb.	*lb.*	*lb.*	*lb.*	*lb.*
Gransville series	625	899	15,499	2,444	6,558
Durham series	635	802	13,288	7,706	1,618
Cecil sandy loam	770	546	45,036	3,100	5,459
Norfolk series	618	529	7,717	5,317	1,800

It will be noted that these soils have relatively low nitrogen and phosphorous contents. Except the Norfolk series, they also have high potash contents. In the Cecil sandy loam soils with high potash content is grown the heaviest tobacco of the bright or flue-cured types. Tobacco with the brightest color is considered of high quality as regards combustibility, aroma, texture, and color.

Digges and Freeman(12), in their observations and physical analysis, claim that the proper soils for flue-cured tobacco in Canada should be a loose, porous sand, containing 40 to 70 per cent medium sand, and not more than 8 to 10 per cent of clay. Sandy soils produce tobacco which cures yellow in color. Very rich soils usually produce a large leaf of poor quality.

McNess and Mathewson(22) claim that no single factor has as much to do with determining the quality of tobacco as the soil upon which it is grown. Hence, great care should be exercised to select the right soil, else the best efforts would be under a serious handicap.

Nicotine contents.—Garner(17) states that although nicotine is the active principle of tobacco its presence in large quantities is not desirable. In fact, the finest grades of tobacco contain only moderate amounts of nicotine. Nicotine exists in two forms, one is soluble in petroleum ether while the other is practically insoluble. The former which is volatile is the one which is responsible for the undesirable sharpness or pungency contained in the smoke. Very rich heavy soils and excessive quantities of nitrogenous fertilizers, which tend to produce a coarse, rank growth, produce a high percentage of nicotine. This is coroborated by the findings of Mukerji(31). Bacon(5) in his studies on the nicotine content of tobacco enumerates the following factors as affecting favorably the nicotine content of tobacco: (1) topping and suckering not only increase the percentage of the alkaloid on the basis of the whole plant but also in the amount produced per plant; (2) with ripening there is a gradual increase in the amount of nicotine in tobacco; (3) heavy nitrogen application produced marked increase in nicotine content of the leaves of *N. rustica.* It is best illustrated by the following results: untreated, 2.5; topped, 4.5; and topped and suckered, 7.44 per cent, and the average amounts of nicotine per plant were 2.66, 5.64 and 9.74 grams, respectively. The progressive change of nicotine content with the ripening of the leaves of the Texas Cuban tobacco was found ranging from 1 to 7 per cent from the time of topping. The fertilizer effect on the nicotine content of tobacco is best illustrated by the application of $NaNO_3$. The different rates of nitrogenous application per acre with their corresponding per cent of nicotine are as follows: 20 pounds, 1.05, 40 pounds, 1.12 and 80 pounds, 2.5 per cent.

Combustibility.—Garner and his associates(14) point out that the first scientific study of the subject was undertaken by Schloessing in 1860 who reached the conclusion that the degree of combustibility of the tobacco leaf is more or less proportional to the content of potash existing in the form of salts of malic and citric acids. McMurtrey(23) and Haley(20) report that the burn of cured tobacco grown with an insufficient supply of potash is very poor. Ames and Boltz(1) and Garner and his associates(14) found in their investigations that tobacco with a low chlorine content has a good fire holding capacity in contrast with the tobacco containing excessive amount of chlorine. With regard to the effect of manure on the burn, Anderson and his associates(2) found that the burn was usually somewhat superior

on the manure plots. As already mentioned Bailey and Anderson(6) found that crop grown on extremely dry season had a poor burn while the crop grown during a season of high rainfall had a good burn. They claim also that all the forms of nitrogen, with the exception of nitrates, are injurious to burn of tobacco. Garner(18) in his experiment on the relation of the chemical composition to the burning qualities of tobacco made the following conclusions: (*a*) the fire-holding capacity is dependent primarily on the content of potash combined with organic acids; (*b*) lime in general does not greatly affect the fire holding capacity, but is an essential factor in the production of good ash; (*c*) large amounts of magnesia tend to injure the capacity for holding fire, (*d*) chlorine injures the burning quality, but it seldom happens that tobacco contains enough of this element to do any serious harm; (*e*) sulphates in general injure the burning qualities, but the effects are not so marked when all the sulphuric acid is combined with potash; and (*f*) so far as is known none of the organic constituents of tobacco with the possible exception of the so-called tarry acids and the albuminoids exert a very important influence on the burning qualities. Liu(21) in his studies on the salt requirement of tobacco found out that a large supply of nitrate produced rough leaves of dark color and poor burning quality.

Experiments in recent years revealed that "the burning quality of tobacco depends upon an abundance of potash in the leaf, with a minimum of chlorine."

Aroma and color.—Moss(30) reports that crop grown on soils of sandy loam character produces leaves with bright color and good aroma. Moss and his associates(28) consider potash as the most important constituent for best quality of flue-cured tobacco. They observed that phosphoric acid is very essential on all soils of the flue-cured districts for the production of tobacco. Anderson and his associates(2) found that liming the land improves the colors of the ash, making it light gray or white, but its influence is very weak compared with the whitening effect of magnesia. It also improves the taste and aroma. Cocke(10) on the other hand claims that lime darkens the color of bright tobacco, while Green(19) reports that in a liming experiment covering four years and involving about 190 plots, the application of lime has not shown beneficial results.

Leow(22) believes that the aroma of tobacco may be injured by various causes, such as, high content of fat or protein. Other

compounds also, interfering seriously with the aroma, appear sometimes to be produced under certain climatic conditions. For example, tobacco produced in Connecticut in the usually wet season of 1897 was absolutely inferior. Vickey and Pucher(36, 37) were able to isolate the following organic acids from the tobacco leaves: malic acid, citric acid, succinic acid, and fumaric acid. With regard to the aromatic acids it was pointed out that very little is known about them.

Other considerations.—Garner(16) is of the opinion that, other things being equal, the leaves harvested by priming have more of the so called "oil" or "gum," greater elasticity, and more body than those cured on the stalk.

Digges(13) in his experiments on the relation of relative humidity in the curing barn to the various stages in the cure, in order to obtain the best results, found that for medium-size crop, the relative humidity should be about 79 per cent when the leaves begin to yellow, 72 per cent when the middle leaves begin to yellow, 60 per cent when the tips begin to yellow, and 47 per cent when the tobacco is yellow enough to begin fixing the color. Digges and Freeman(12) claim that, of the various methods followed in harvesting tobacco, the split method has produced the best, both from the standpoint of economy and the final color of the cured leaf. McNess and his associates(24) claim that the local temperature at which the tobacco dries is unfavorable to the chemical changes that take place in the leaf to develop the desirable colors.

Brown and Lunn(18), in their rotation experiments with tobacco for a period of eleven years, report that on the whole the quality of the tobacco grown under the different cropping systems involving the use of legumes was fairly good during the first few years of the tests. As the experiments progressed, there was a considerable decline in quality.

Loew(22) reports that well ripened leaves yield, when normally cured, the so called "gummy" leaves with well developed grain, while unripe leaves and over-ripe leaves will produce an inferior product. Hence, the single-leaf curing process would be preferable to the method of curing on stalk, since the over-ripe, ripe, and unripe leaves are in the latter method harvested together, to be cured under equal conditions.

The present writers(33) in their previous investigations recommend that if sun curing is practised at all, in order to obtain yellow leaves it should be in regions where there are distinct

wet and dry seasons. And in curing, the leaves should be thoroughly dried as any excess moisture in the leaves will encourage the growth of molds. They(34) also found out that the proper time to harvest the leaves is when they assume light-green color. At this stage it is claimed that the leaves will turn yellow in curing. They(32) also recommend that in regions like the Cagayan Valley where sun-curing is not practicable owing to uncertain weather conditions or because of the short dry period, flue-curing has to be resorted to.

MATERIALS AND METHODS

Three varieties of the locally produced Virginia tobacco including one grade of the imported leaves were studied in these experiments. They were the Adcock, North Carolina Bright Yellow, White Stem Orinoco, and the Lexington 1933 crop.

FIELD CULTURE

In all cases the seeds of the locally grown tobacco were sown in the seed-beds during the month of October and transplanted in the field in about the latter part of November or when they were about two months old. The plants were set out in the field 70 by 80 centimeters. The care given to the plants was practically the same for all cultures. Harvesting was done by priming. All the leaves used in the experiments were of the 1933–1934 crop. They were all sun cured. The leaves had been aged for about one year before they were studied.

RAINFALL AND TEMPERATURE

The average monthly and annual rainfalls and the normal monthly and annual temperatures from 1928–1931 were obtained from the annual reports of the Philippine Weather Bureau. (See Tables 1, 2, and 3.) The average monthly and annual rainfalls in four districts in the United States where Virginia tobacco is grown is also given. The monthly rainfall and temperature for the 1933–1934 tobacco season are given in Table 4.

COLOR OF CURED LEAVES

A direct comparison of the color of the leaves of each variety produced in different localities were made. The color of the leaves of all the varieties were also compared and they were arranged in their order of yellowness. (See results in Table 3.) In determining the color of the leaves, the "Color Standards and Nomenclature," by Robert Ridgway was used as reference.

THICKNESS OF LAMINA AND VEINS

Exactly 100 leaves were used for each variety in this study. The leaves were picked up at random. Only one measurement was taken from each leaf for both vein and lamina. The measurement was taken at the center of one-half of the leaf and was done with the use of Perkins Micrometer Dial Gage. The measurements were expressed in microns. (See results in Tables 6 and 7.)

FIRE HOLDING CAPACITY

Several leaves from each variety were stripped longitudinally about two centimeters wide and ten centimeters long. Exactly 100 strips were picked up at random from each variety. The stripped leaves were then placed in an oven at constant temperature (40° C.) for three days. With the use of a lighted burner each strip was ignited one by one and the time of duration of the glow was recorded. The time was recorded by means of a stop watch. This experiment was performed in a room where all the windows were closed. (See results in Table 8.)

COMPARATIVE ANALYSIS OF TOBACCO LEAVES

The chemical analysis of the leaves was made by the Agricultural Chemistry Section of the Bureau of Plant Industry. The following components were determined: moisture, ash, nicotine, nitrogen, potassium, calcium, magnesium, and chlorides. (See results in Tables 9 and 10.) The official and tentative methods of analysis of the association of Official Agricultural Chemists(4) were used.

Studies were also made on the effect of sun-curing and flue-curing on the moisture and nicotine content of the leaves. In these studies the Adcock and the North Carolina Bright Yellow varieties were used. The leaves were harvested, cured, and analyzed at the same time. The materials were obtained from Hacienda Tala of the Gold Leaf Tobacco Co., Inc., at Novaliches, Rizal. (See results in Table 11.)

DISCUSSION OF RESULTS

CLIMATIC CONDITIONS

Rainfall.—Tables 1 and 2 show the average monthly and annual rainfall in four districts in the United States and the Philippines where Virginia tobacco is grown. It is evident that the average annual rainfall (2,046 to 2,357 mm.) in the Philippine cigarette tobacco districts is twice as much as that in the

United States (1,030 to 1,109 mm.). In the Philippines the seed-bed period is from September to November; the planting season from November to December while the harvesting period is during the months of February, March, and April. As shown in Table 2 the average monthly rainfall in the four cigarette tobacco districts in the Philippines during the month of September ranges from 217 to 309 millimeters; October, 136 to 209; and November, 37 to 96 millimeters. In Ilocos Norte where the average monthly rainfall during the month of November is only 37 millimeters it seems that planting should commence earlier. Under no circumstances should planting be made later than November in any district because there is hardly very little or no more rain after that time. During the month of December the average monthly rainfall ranges from 3 to 33 millimeters only. In the Philippines it is practically dry during the harvesting season, especially in the months of February and April, hence it is ideal for sun-curing.

In Table 4 the monthly rainfalls during the 1933–1934 tobacco season are given.

Temperature.—With regard to temperature it is practically uniform in the four districts in the Philippines under consideration. (See table 3.) The highest temperature was recorded during the months of March and April or during the harvesting season. The months with the lowest temperature were November, December, and January, or during the planting season and growing period of the plants.

The monthly temperatures during the 1933–1934 tobacco season are also given in Table 4.

COLOR OF LEAVES

There were altogether 11 samples studied: one imported and 10 local. The leaves were compared and arranged in the order of their yellowness. It may be recalled that yellowness is one of the most important characters that determine the quality of aromatic cigarette leaf tobacco. Referring to Table 5 one will see that in point of yellowness the imported leaves ranked first, followed by North Carolina Bright Yellow, White Stem Orinoco, and Adcock. It should be mentioned that the imported leaves were flue-cured while the local products were only sun-cured. The superiority in color of the imported leaves is probably due to the method of curing employed because in our previous work in 1930 and 1932 we succeeded also in producing leaves with bright yellow color by means of flue-curing. Of all the samples

produced locally the North Carolina Bright Yellow had the best color of leaves. However, the color of the leaves produced in different places of the same variety varies in degree of yellowness. As for instance, the leaves produced in Maligaya, Nueva Ecija, had better color than those produced either in Dingras, Ilocos Norte, or Rosales, Pangasinan. The same thing was true with the variety White Stem Orinoco. Adcock grown in Rosales, Pangasinan, produced the best color of leaves followed by those from Dingras, Ilocos Norte, Maligaya, Nueva Ecija, and Angeles, Pampanga. In so far as the color of the leaves is concerned, the North Carolina Bright Yellow and White Stem Orinoco varieties are best adapted to Nueva Ecija conditions, and Adcock to Pangasinan.

THICKNESS OF LEAVES

Veins.—Referring to Table 6, one will readily see that the veins of the leaves of the locally produced Virginia tobacco are generally more prominent than those of the imported leaves. As for instance, the mean thickness of the Lexington 1933 crop was only 413 ± 5.245 microns; while the mean thickness of the locally produced leaves ranges from 431.5 ± 6.554 to 539.5 ± 7.773 microns. This is probably because the former was produced under a more xeric condition and as such they had more developed zylem vessels. That it is more xeric in the tropics than in the temperate zone is obvious. If we, therefore, take the thickness of the veins of the imported leaves as standard, it is evident that the locally produced leaves are inferior in this particular character. It might be mentioned in this connection that in the manufacture of cigarettes the entire leaves are chopped, including the midribs and veins. Leaves with prominent veins are therefore not ideal.

Lamina.—An examination of Table 7 will reveal the fact that there is practically little or no difference between the locally produced leaves and the imported leaves in thickness of lamina. The mean thickness of the imported leaves was 112.1 ± 1.403 microns. On the other hand the thickness of lamina of the local samples studied ranges from 98.6 ± 1.644 to 114.6 ± 1.708 microns. The five samples which approached the imported leaves in thickness of lamina were as follows: Adcock (Angeles, Pampanga), 110 ± 1.652, North Carolina Bright Yellow (Maligaya, Nueva Ecija), 110.3 ± 1.632, Adcock (Dingras, Ilocos Norte), 113 ± 1.509, White Stem Orinoco (Dingras, Ilocos Norte),

113.7 ± 1.948, and North Carolina Bright Yellow (Dingras, Ilocos Norte), 114.6 ± 1.708 microns. Note that all the samples raised in Dingras, Ilocos Norte, have practically the same thickness of lamina as the imported leaves.

FIRE HOLDING CAPACITY

A study of Table 8 will show that the fire-holding capacity of the locally produced leaves was better than that of the imported leaves with a mean of 8.10 ± 0.287 seconds only. Except the White Stem Orinoco from Dingras, Ilocos Norte, which has a mean fire-holding capacity of 5.50 ± 0.590 seconds all the rest were better than the imported leaves. The local samples with fire-holding capacity above 20 seconds were as follows: North Carolina Bright Yellow (Maligaya, Nueva Ecija), 20.30 ± 0.874, North Carolina Bright Yellow (Dingras, Ilocos Norte), 20.80 ± 0.888, North Carolina Bright Yellow (Rosales, Pangasinan), 26.00 ± 0.851, White Stem Orinoco (Angeles, Pampanga), 26.05 ± 0.807, and Adcock (Angeles, Pampanga), 27.25 ± 0.898 seconds. Note that the variety North Carolina Bright Yellow raised in three different places had the best fire-holding capacity.

COMPARATIVE ANALYSIS OF LEAVES

Moisture.—A study of Table 9 shows that the moisture content of the locally produced leaves ranges from 9.70 to 13.79 per cent. The imported leaves with 15.04 per cent moisture had a higher moisture content than any of the local samples. This is probably one of the reasons why the fire-holding capacity of the imported leaves is relatively poor. (See Fig. 1.)

Ash.—It will be seen from the same table that any one of the local products had a much higher ash content than the imported leaves. The ash content of the Lexington 1933 crop was 10.43 per cent on fresh basis and 12.28 per cent on dry basis while the ash content of the locally produced leaves ranged from 13.66 to 23.58 per cent on fresh basis and 15.63 to 26.11 per cent on dry basis. It is also true that the local samples had a wide range of variation in their ash content. The ash content does not seem to have any direct correlation with the fire-holding capacity as far as the present results are concerned. For instance, the imported leaves with the least ash content had a poor combustibility. On the other hand, among the samples studied, the variety White Stem Orinoco grown in Din-

gras, Ilocos Norte, had the highest ash content and yet it had also the poorest fire-holding capacity. (See Fig. 1.)

Nicotine.—The majority of the local samples studied compare favorably with the imported leaves in nicotine content. The imported leaves had an average nicotine content of 1.31 per cent on fresh basis and 1.54 per cent on dry basis. Note that all the varieties grown in Maligaya, Nueva Ecija, contained a high percentage of nicotine or more than two per cent on the dry basis. They may be enumerated as follows: White Stem Orinoco, 2.13, North Carolina Bright Yellow, 2.30, and Adcock, 2.27 per cent. Those leaves produced in Angeles, Pampanga, had the lowest nicotine content or 0.36 per cent on fresh basis and 0.41 per cent on dry basis for Adcock and 0.44 per cent on fresh basis and 0.49 per cent on dry basis for White Stem Orinoco. (See Fig. 1.) As a rule, although nicotine is the active principle of tobacco, its presence in excessive quantity in the leaves is not desirable. In other words the ideal leaves for smoking are those containing the minimum amount of nicotine.

Nitrogen.—Nitrogen, when present in the leaves in excess, according to the findings of previous investigators, is not desirable as it renders poor burning quality. In the present study the nitrogen contents of practically all the local samples were lower than those of the imported leaves. The only ones with high nitrogen content were the White Stem Orinoco (Maligaya, Nueva Ecija) and North Carolina Bright Yellow (Rosales, Pangasinan). The nitrogen content ranges from 1.63 to 2.36 per cent on fresh basis and 1.84 to 2.67 per cent on dry basis for the local samples and 2.47 per cent for the imported. (See Fig. 1.)

Chlorides.—Chlorine, according to Garner(18) and Ames et al.(1), when present in the leaves in abundance is injurious to the burning quality. It will be seen in Table 10 that on the whole the local samples contained more chlorine than the imported leaves. Our analysis show that the latter contained only 0.15 per cent of chlorine. The only sample which contained less chlorine than the imported leaves was Adcock raised in Angeles, Pampanga, with 0.01 per cent. The other samples contained chlorine ranging from 0.16 to 0.66 per cent. Garner(18), however, claims that it seldom happens that tobacco contains enough of this element to do any serious harm. A close examination of Tables 8 and 10 will show that there is a close rela-

tionship between the fire-holding capacity and the chlorine content of the leaves, i. e., those samples with low chlorine content have generally good fire-holding capacity. As for instance, the Adcock variety raised in Maligaya, Nueva Ecija, which has the best fire-holding capacity or 27.25 ± 0.898 seconds, has also the lowest chlorine content, 0.01 per cent. The same thing was also true in the case of the North Carolina Bright Yellow variety. The leaves raised in Angeles, Pampanga, and Maligaya, Nueva Ecija, were in accord with the results for the other two varieties mentioned. The variety White Stem Orinoco raised in Dingras, Ilocos Norte, was, however, an exception. The leaves contained only a moderate amount of chlorine and yet they had poor fire-holding capacity. (See Fig. 1.)

Lime.—It has been reported by Garner(18) and Anderson et al.,(2) that lime does not greatly affect the fire-holding capacity but improves the color of the ash. In the present study the color of the ash of the samples under consideration was not determined. It will be seen in Table 10 that the imported leaves contained 23.41 per cent lime (CaO). Only four of the local samples contained as much or more, all the rest were deficient in this element as compared with the imported leaves. The samples which contained high percentage of lime were as follows: Adcock (Dingras, Ilocos Norte), 39.97, North Carolina Bright Yellow (Maligaya, Nueva Ecija), 26.32, Norte Carolina Bright Yellow (Rosales, Pangasinan), 27.44, and White Stem Orinoco (Dingras, Ilocos Norte), 26.89 per cent. (See Fig. 1.)

Magnesia.—Garner(18) reports that a large amount of magnesia (MgO) tends to injure the capacity for holding fire. Anderson and his associates(2) found that magnesia has a better whitening effect on the ash than lime. By looking at Table 10 it will be noted that the imported leaves contained 8.24 per cent magnesia which is much higher than the local samples, excelled only by North Carolina Bright Yellow raised in Maligaya, Nueva Ecija, which contained 8.26 per cent. This is probably another reason why the imported leaves had poor fire-holding capacity. The percentage of magnesia for the rest of the local samples ranges from 2.36 to 5.59 per cent. (See Fig. 1.)

Potash.—As already mentioned, the results of previous investigations prove that the burning quality of tobacco depends largely upon the abundance of potash in the leaf. It is strange, however, that the results of the present investigation do not quite conform with this theory, because, although the imported

leaves contained 17.71 per cent potash which was excelled only by North Carolina Bright Yellow grown in Dingras, Ilocos Norte, with 19.01 per cent potash yet its fire-holding capacity was relatively poor. It is probable, therefore, that there are other factors responsible for good burning quality. In other words an abundance of potash alone is not sufficient to render a good fire-holding capacity. As already mentioned, since the imported leaves contained a high percentage of nitrogen, moisture, and magnesia all of which have an unfavorable effect on fire-holding capacity, it is probable that their presence in abundance exerted a stronger influence than potash.

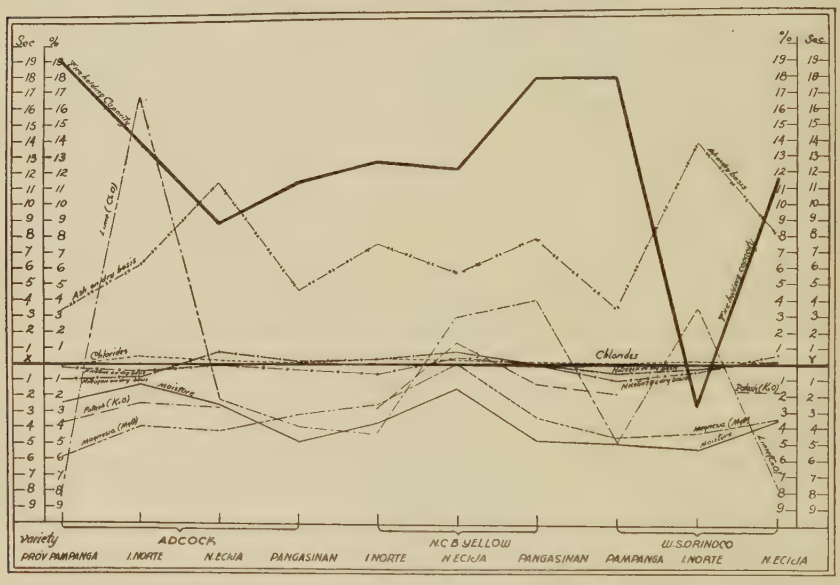

FIG. 1. Chart wherein the chemical analysis and fire-holding capacity of the locally grown Virginia tobacco leaves are compared with the imported product, using the latter as standard represented by line XY.

The local samples except North Carolina Bright Yellow from Maligaya, Nueva Ecija, have practically a uniform potash content ranging from 14.01 to 16.43 per cent which, evidently with only one exception, have also a uniform fire-holding capacity.

EFFECT OF CURING ON THE MOISTURE AND NICOTINE CONTENT OF THE LEAVES

Referring to Table 11, one will readily see that both the moisture and nicotine content were much higher in the flue-cured leaves than those of the sun-cured for both varieties. For the Adcock variety there was a difference in moisture content

of 5.27 per cent and 3.91 per cent for North Carolina Bright Yellow. This difference was probably due to the fact that the leaves placed under the sun took longer time to cure (15 to 21 days) than those placed in the flue-curing barn (2 to 3 days); hence, respiration process manifested longer. In addition to water lost by evaporation there was a big quantity of physiological water lost (by respiration). It is probable, therefore, that less water was lost in the flue-curing process than in the sun-curing.

The nicotine content of the flue-cured tobacco was more than twice as much as that of the sun-cured (Table 11). According to Collison et. al.,(11) nicotine has a considerable volatility at ordinary temperatures. Although the heat of the sun has an average temperature of about 33° C. which was only one-half of the heat in the flue-curing barn (66° C.) under which the leaves were cured, yet, because of the big difference in time under which the leaves were subjected, more nicotine was probably volatilized in the former than in the latter.

OBSERVATIONS ON AROMA AND KEEPING QUALITY OF LEAVES

We have observed that the imported leaves were generally more aromatic than the locally produced leaves (either sun-cured or flue-cured). The superiority of the imported leaves may be due to several factors such as soil and climate and also the method of packing and aging the leaves. With the imported leaves baling is done with the use of hydraulic pressure; hence they are very compact. In view of this the aroma is well conserved. The local product as a rule is baled like the ordinary native filler tobacco in which case a good portion of the aroma could escape. This is also the reason why the imported leaves, unlike the native product, could be kept for an indefinite length of time without being attacked by molds. In fact the greatest objection of the local manufacturers to the locally produced Virginia tobacco is that it is easily attacked by molds. This defect is of course objectionable but remediable. Studies along this line are, therefore, highly in order.

SUMMARY AND CONCLUSION

In the cigarette tobacco districts of the Philippines the average annual rainfall is twice as much as that in some districts in the United States where Virginia tobacco is grown commercially. In the Philippines, however, planting in the field should not be made later than November as there is scarcely very

little or no more rain after that time to give the plants a good start in the field.

In Central and Northern Luzon provinces, particularly Pampanga, Nueva Ecija, Pangasinan, and Ilocos Norte, curing of the leaves in the sun is practicable as the harvesting of the leaves coincides with the driest months—February, March, and until the middle of April.

Among the locally produced Virginia tobacco varieties studied, North Carolina Bright Yellow ranked first in color of leaves and was almost as yellow as the imported leaves.

The veins of the leaves of the locally grown aromatic Virginia tobacco ranges from 431.5 ± 6.554 to 539.5 ± 7.773 microns and are more prominent than those of the imported leaves but the laminas are practically of the same thickness. In some cases the lamina of the former is even thinner.

The local samples except one have a much better fire-holding capacity or with an average of more than 20 seconds as against eight seconds for the imported.

The analysis of the leaves shows that the local products have generally lower moisture content, higher percentage of ash and chlorides, and less magnesia (MgO) than the imported leaves.

Fifty per cent of the samples contained more nicotine than the imported leaves. The samples which contained the least nicotine were those produced in Angeles, Pampanga. The average nicotine content of the local samples ranges from 0.36 to 1.99 per cent on fresh basis and 0.41 to 2.30 per cent on dry basis. The imported leaves had an average nicotine content of 1.31 and 1.54 per cent on fresh and dry bases, respectively.

Only three of the local samples contained higher percentage of nitrogen than the imported leaves, the other seven contained less. The former had 2.10 per cent nitrogen on fresh basis and 2.47 per cent on dry basis.

Out of the 10 local samples studied only four contained more lime (CaO) than the imported leaves. The latter contained 23.41 per cent of this element, and the former ranging from 14.99 to 27.44 per cent.

The local samples, with the exception of one in which the percentage of potash was 19.01 per cent, generally had lower potash content than the imported leaves, ranging from 14.01 to 15.43 per cent. The average potash content of the imported leaves was 17.71 per cent. In spite of the high potash content of the imported leaves, however, their fire-holding capacity was

much poorer than that of the local products. An abundance of this element alone in the leaves is not therefore a sufficient guarantee for good combustibility. In our opinion the high moisture content of the imported leaves was responsible for the poor fire-holding capacity. The imported leaves contained 15.04 per cent moisture and from 9.7 to 13.5 per cent only for the local products.

Two methods of curing were studied: sun-curing and flue-curing. The method of curing had a great influence on the moisture and nicotine content of the leaves. For instance, for the two varieties studied the analysis of the leaves shows that those which were flue-cured contained a much higher percentage of moisture and nicotine than those which were cured under the sun. The sun-cured leaves of the Adcock variety contained 5.27 per cent less moisture than the flue-cured leaves and North Carolina Bright Yellow 3.91 per cent less. The nicotine contents of the flue-cured leaves were more than double those of the sun-cured for both varieties.

It has been observed that the imported leaves can be kept much longer than the native products owing to the excellent method of packing employed. It is very necessary that studies along this line should be conducted.

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TABLE 1.—*Showing average monthly and annual rainfall in four districts in the United States where Virginia tobacco is grown*

Stations	Length of record	January	February	March	April	May	June	July	August	September	October	November	December	Annual
	yrs.	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*
Danville, Va.	5	70	69	111	87	71	107	98	76	95	79	76	90	1,030
Reidoville, N. C.	12	94	99	116	93	100	112	104	114	77	69	60	86	1,109
Henderson, N. C.	12	100	76	96	96	106	108	152	108	74	72	59	87	1,032
Florence, S. C.	6	80	72	65	77	103	102	211	132	82	68	35	76	1,104

TABLE 2.—*Showing average monthly and annual rainfall, 1928–1931, in four districts in the Philippines where Virginia tobacco is grown*

Stations	January	February	March	April	May	June	July	August	September	October	November	December	Annual
	mm.	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*
San Isidro, Nueva Ecija	9	9	12	34	257	240	368	467	309	209	96	33	2.046
Dagupan, Pangasinan	18	15	8	57	245	328	569	593	293	136	84	9	2 357
Laoag, Ilocos Norte	3	0	5	11	222	302	486	619	217	176	37	3	2.081
Del Carmen, Pampanga	12	11	12	42	210	312	490	591	228	142	87	23	2.160

TABLE 3.—*Showing normal monthly and annual temperature, 1928–1931*

Stations	January	February	March	April	May	June	July	August	September	October	November	December	Average total
	°C.	°C.	°C.	°C.	°C.	°C.	°C.	°C.	°C.	°C.	°C.	°C.	°C.
San Isidro, Nueva Ecija	25.67	26.34	28.02	29.38	29.58	28.36	27.58	27.43	27.87	27.51	26.67	25.95	27.53
Dagupan, Pangasinan	26.37	26.97	28.58	29.98	29.57	28.57	27.73	27.53	28.08	27.71	27.26	26.49	27.91
Laoag, Ilocos Norte	25.55	25.76	27.36	28.89	29.34	28.31	27.78	27.46	27.86	27.24	26.78	26.02	27.36
Del Carmen, Pampanga	26.12	26.81	28.18	29.31	29.61	28.12	27.18	26.93	27.31	26.98	26.62	26.12	27.44

TABLE 4.—*Monthly rainfall and temperature during the 1933–1934 tobacco season*

Month	Del Carmen, Pampanga		Muñoz, Nueva Ecija		Dagupan, Pangasinan		Laoag, Ilocos Norte	
	Rainfall	Temperature	Rainfall	Temperature	Rainfall	Temperature	Rainfall	Temperature
1933								
	mm.	°C.	mm.	°C.	mm.	°C.	mm.	°C.
September	400.1	26.8	202.2	[1]	760.3	26.8	268.5	26.9
October	204.7	26.3	224.2		111.3	26.9	67.6	26.8
November	56.9	26.5	149.3		104.3	26.3	8.7	25.7
December	11.2	26.3	2.0		10.4	25.9	35.3	24.8
1934								
January	8.4	26.3	0.0		3.8	25.3	0.0	24.4
February	45.0	26.3	22.2		27.1	25.7	37.9	25.0
March	12.7	27.8	89.6		1.8	26.9	0.0	26.3
April	67.5	28.5	107.4		130.3	28.3	1.0	28.2

[1] Figures are not available.

TABLE 5.—*Showing color of leaves produced from different localities arranged in their order of yellowness*

Variety	Locality	Color of leaf [1]
I. Imported leaves, (Genuine Virginia)	Lexington Ky. 1933 crop	Ranging from Colonial-Buff to Chamois.
II. North Carolina Bright Yellow	1. Maligaya, Nueva Ecija	Ranging from Antimony Yellow to Ochraceous-Tawny.
	2. Dingras, Ilocos Norte	Ranging from Ochraceous-Buff to Buckthorn Brown.
	3. Rosales, Pangasinan	Ranging from Buckthorn Brown.
III. White Stem Orinoco	1. Maligaya, Nueva Ecija	Ranging from Clay color to Cinnamon.
	2. Dingras, Ilocos Norte	Ranging from Clay color to Sayal Brown.
	3. Angeles, Pampanga	Ranging from Snuff Brown to Cinnamon Buff.
IV. Adcock	1. Rosales, Pangasinan	Ranging from Clay color to Tawny Olive.
	2. Dingras, Ilocos Norte	Ranging from Cinnamon-Buff to Clay color.
	3. Maligaya, Nueva Ecija	Ranging from Pinkish Buff to Tawny Olive.
	4. Angeles, Pampanga	Ranging from Tawny Olive to Saccardo's Umber.

[1] Color of leaves were referred to Color Standards and Nomenclature by Robert Ridgeway, Washington, D. C., 1919.

TABLE 6.—*Frequency distribution of thickness of vein of tobacco leaves*

Class center	Adcock				White Stem Orinoco		
	Maligaya, Nueva Ecija	Angeles Pampanga	Rosales, Pangasinan	Dingras, Ilocos Norte	Maligaya, Nueva Ecija	Angeles, Pampanga	Dingras, Ilocos Norte
Seconds							
225		2	1	1	1	1	1
275	2	9	1	4	1	9	4
325	10	9	2	4	8	9	8
375	9	17	5	9	5	11	15
425	15	22	12	18	18	15	9
475	15	18	16	15	17	16	9
525	16	8	20	20	14	16	16
575	14	11	17	14	7	7	12
625	6	4	8	4	6	8	11
675	5		8	8	10	4	9
725	4		5	3	7	2	5
775	4		4		4	2	1
825			1		2		
Total	100	100	100	100	100	100	100
Mean	502.5 ±8.215	431.5 ±6.554	539.5 ±7.773	494 ±7.388	524 ±9.102	468.5 ±8.429	503 ±9.352
Standard deviation	121.7 ±5.805	97.1 ±4.632	115.15±5.493	109.45±5.221	134.85±6.432	123.40±5.986	138.55±6.609
Coefficient of variability	24.21±1.213	22.50±1.116	21.34±1.069	22.15±1.098	25.73±1.301	26.34±1.331	27.54±1.406

TABLE 6.—*Frequency distribution of thickness of vein of tobacco leaves*—Continued

Class center	N. C. B. Yellow			Imported leaves Lexington 1933 crop
	Maligaya, Nueva Ecija	Rosales, Pangasinan	Dingras, Ilocos, Norte	
Seconds				
225	1	4		
275	3	10	3	5
325	5	12	4	15
375	8	13	11	27
425	19	12	11	24
475	11	15	13	18
525	15	11	14	5
575	18	9	16	4
625	9	7	8	1
675	10	5	7	1
725	5	2	6	
775	6	7	7	
825				
Total	100	100	100	100
Mean	536 ±8.758	448 ±8.522	531.5 ±8.768	413.5 ±5.245
Standard deviation	129.75±6.189	126.25±6.022	129.90±6.196	77.70±3.706
Coefficient of variability	24.21±1.213	28.18±1.438	24.44±1.166	18.79±0.923

TABLE 7.—*Frequency distribution of thickness of lamina of tobacco leaves*

Class centers	Adcock				White Stem Orinoco		
	Maligaya, Nueva Ecija	Angeles, Pampanga	Rosales, Pangasinan	Dingras, Ilocos Norte	Maligaya, Nueva Ecija	Angeles, Pampanga	Dingras, Ilocos Norte
Seconds							
55	4	2	5		2	6	4
65	9	6	6	3	5	7	6
75	12	7	8	5	7	12	7
85	12	8	9	11	9	11	8
95	14	10	11	11	12	16	6
105	19	12	12	12	15	18	9
115	9	10	13	15	15	10	11
125	11	25	20	18	18	11	13
135	4	12	13	14	9	3	17
145	2	5	2	8	5	3	10
155	2	3	1	3	3	3	8
165	2						1
Total	100	100	100	100	100	100	100
Mean	99.3 ±1.391	110 ±1.652	105.3 ±1.663	113 ±1.509	108.2 ±1.588	98.6 ±1.644	113.7 ±1.948
Standard deviation	20.603±0.983	24.47±1.167	24.63±1.175	22.36 ±1.067	23.53±1.122	24.35±1.161	28.86±1.377
Coefficient of variability	20.74±1.029	22.21±1.101	23.39±1.171	19.78±0.972	21.74±1.078	24.69±1.237	25.38±1.282

TABLE 7.—*Frequency distribution of thickness of lamina of tobacco leaves*—Continued

Class centers	N. C. B. Yellow			Imported leaves, Lexington 1933 crop
	Maligaya, Nueva Ecija	Rosales, Pangasinan	Dingras Ilocos Norte	
Seconds				
55	3	3	2	
65	5	4	4	2
75	4	10	6	7
85	9	12	4	7
95	9	13	10	13
105	17	18	15	13
115	15	16	15	17
125	14	12	14	23
135	15	9	16	11
145	6	3	6	4
155	3		5	3
165			3	
Total	100	100	100	100
Mean	110.3 ±1.632	103.1 ±1.477	114.6 ±1.708	112.1±1.403
Standard deviation	24.18±1.153	21.88±1.044	25.31±1.207	20.79±0.992
Coefficient of variability	21.92±1.087	21.22±1.053	22.08±1.095	18.54±0.911

TABLE 8.—*Frequency distribution of fire-holding capacity of cigarette tobacco leaves*

Class centers	Adcock				White Stem Orinoco		
	Maligaya, Nueva Ecija	Angeles, Pampanga	Rosales, Pangasinan	Dingras, Ilocos Norte	Maligaya, Nueva Ecija	Angeles, Pampanga	Dingras, Ilocos Norte
Seconds							
5	14		2	3	4		66
10	25		18	19	23	6	12
15	18	15	23	31	19	9	9
20	16	16	19	22	8	10	6
25	8	16	8	4	14	22	2
30	5	16	7	6	9	15	2
35	4	13	7	5	5	14	1
40	2	8	3	3	4	10	1
45	2	5	5	1	6	6	0
50	2	4	3	1	3	2	0
55	2	4	2	1	1	2	0
60	2	3	3	4	4	4	1
Total	100	100	100	100	100	100	100
Mean	15.00±0.881	27.25±0.898	19.55±0.907	16.75±0.837	19.65±0.962	26.05±0.807	5.50±0.590
Standard deviation	13.05±0.622	13.30±0.634	13.45±0.642	12.40±0.591	14.25±0.680	11.95±0.570	8.75±0.417
Coefficient of variability	87.00±6.557	48.81±2.817	68.85±4.499	74.03±5.083	72.52±4.946	45.87±2.604	159.09±18.669

TABLE 8.—*Frequency distribution of fire-holding capacity of cigarette tobacco leaves*—Continued

Class centers	N. C. B. Yellow			Imported leaves, Lexington 1933 crop
	Maligaga, Nueva Ecija	Rosales, Pangasinan	Dingras, Ilocos Norte	
Seconds				
5			1	10
10	14	1	13	50
15	28	12	20	30
20	15	20	21	8
25	11	22	14	2
30	10	11	10	
35	5	10	6	
40	3	6	2	
45	5	4	1	
50	6	5	6	
55	1	6	4	
60	2	3	2	
Total	100	100	100	100
Mean	20.30±0.874	26.00±0.851	20.80±0.888	8.10±0.287
Standard deviation	12.95±0.618	12.60±0.601	13.15±0.627	4.25±0.203
Coefficient of variability	63.79±4.078	48.46±2.798	63.22±4.041	52.47±3.104

TABLE 9.—*Comparative analysis of leaves of cigarette tobacco grown in different regions*

Sample	Moisture	Ash	Nicotine		Nitrogen	
			Fresh basis	Dry basis	Fresh basis	Dry basis
Adcock:						
Angeles, Pampanga	12.60	13.66	0.36	0.41	1.91	2.18
Dingras, Ilocos Norte	13.79	15.93	0.56	0.65	1.72	1.99
Maligaya, Nueva Ecija	12.46	20.73	1.99	2.27	2.05	2.34
Rosales, Pangasinan	10.15	15.23	1.59	1.77	1.89	2.10
North Carolina Bright Yellow:						
Dingras, Ilocos Norte	11.30	17.55	1.57	1.77	1.63	1.84
Maligaya, Nueva Ecija	13.50	15.54	1.99	2.30	2.44	2.82
Rosales, Pangasinan	10.24	18.06	1.31	1.46	2.26	2.52
White Stem Orinoco:						
Angeles, Pampanga	10.02	14.17	0.44	0.49	1.67	1.86
Dingras, Ilocos Norte	9.70	23.58	0.93	1.03	1.93	2.14
Maligaya, Nueva Ecija	11.53	17.89	1.88	2.13	2.36	2.67
Imported leaves:						
Lexington Ky. 1933 crop	15.04	10.43	1.31	1.54	2.10	2.47

TABLE 10.—*Partial ash analysis of leaves of cigarette tobacco grown in different regions*

Sample	Ash on dry basis	Chlorides	Lime (CaO)	Magnesia (MgO)	Potash (K_2O)
Adcock:					
Angeles, Pampanga	15.63	0.01	14.99	2.36	14.01
Dingras, Ilocos Norte	18.48	0.66	39.97	4.31	16.25
Maligaya, Nueva Ecija	23.68	0.34	21.12	3.98	15.98
Rosales, Pangasinan	16.95	0.23	19.48	5.11	
North Carolina Bright Yellow:					
Dingras, Ilocos Norte	19.79	0.43	18.99	5.59	14.93
Maligaya, Nueva Ecija	17.97	0.44	26.32	8.26	19.01
Rosales, Pangasinan	20.12	0.19	27.44	4.93	16.43
White Stem Orinoco:					
Angeles, Pampanga	15.75	0.16	18.48	3.63	15.92
Dingras, Ilocos Norte	26.11	0.28	26.89	3.93	
Maligaya, Nueva Ecija	20.22	0.30	15.73	4.76	15.98
Imported leaves:					
Lexington Ky. 1933 crop	12.28	0.15	23.41	8.24	17.71

TABLE 11.—*Showing the moisture and nicotine content of two varieties of Virginia tobacco produced in Novaliches, Rizal, during the 1934–35 season as affected by the method of curing.*

Sample	Moisture	Nicotine	
		Fresh basis	Dry basis
Adcock (sun-cured)	8.09	1.08	1.18
Adcock (flue-cured)	13.36	2.25	2.59
N. C. B. Y. (sun-cured)	10.10	0.80	0.89
N. C. B. Y. (flue-cured)	14.01	1.81	2.10

ILLUSTRATION

TEXT FIGURE

FIG. 1. Chart wherein the chemical analysis and fire-holding capacity of the locally grown Virginia tobacco leaves are compared with those of the imported product, using the latter as standard, represented by line XY.

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ROOT AND TOP DEVELOPMENT OF TOBACCO PLANT WITH SPECIAL REFERENCE TO THE CIGAR WRAPPER TYPE

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ONE PLATE AND TWO TEXT FIGURES

The degree of development of the part of the plant above the ground is dependent to a great extent upon the distribution and activities of the root system. Although the growth, extent of penetration, or lateral spread of the roots of plants may be controlled to a certain extent by various methods of culture(1), yet root habits are governed by the hereditary growth character of the species or variety in question(2). Thus, it is obvious that a study of root development of our cultivated plants, of their positions, extent, and activities as absorbers of water and nutrients at various stages of growth is of great importance specially to those who are engaged in crop production.

A thorough understanding of the root system of each of our major crops is essential before one could properly apply the appropriate methods of culture and fertilizers. A clear mental picture of the plant as a whole may enable one to find the solution of some of the problems which need immediate attention, namely: (1) relation of roots to soil moisture; (2) root responses to low water content; (3) relation of roots to cultural practices as transplanting and the application of fertilizers, etc.; (4) root habit and depth of intertillage; (5) relation to crop rotations, cover crops and intercropping; (6) soil erosion; and (7) weed eradication.

It is to be regretted that our knowledge of the root habits of the major crops in the Philippines is very meager, and in many cases wanting; hence, this work was undertaken. The

root system of the tobacco plant was first studied. The underground parts of the other crops like corn, rice, sugar cane, abacá, and others will also be investigated.

The work was carried out at the Central Experimental Station, Malate, Manila from September, 1934, to March, 1935.

GENERAL CONDITIONS FOR GROWTH DURING THE TOBACCO SEASON IN MANILA

The mean precipitation in Manila during the months of December, January, February, and March (tobacco growing season) over a period of 69 years is 113.0 mm.[1]. This is distributed as follows: 59.9 mm. for December; 24.2 for January; 11.4 for February; and 17.5 mm. for March. The mean temperature of the air during the same months ranges from 24.7 to 26.6° C. and the relative humidity is from 81.1 to 71.3 per cent. Total evaporation in free exposure (Piche tube) per month ranges from 87.9 to 179.3 mm. or a total of 502.1 mm. for four months. Wind movement is fairly constant and moving at a low rate as compared with the latter part of the year when the tobacco plants are not growing.

The growing season of 1935 was normal. Well distributed rains occurred during the early vegetative growth of the tobacco seedlings, providing sufficient water in the soil for the growth of young plants. There was a total of 130.9 mm. of precipitation as against an average of 113 mm. rain during a period of 69 years. This was accompanied by moderate temperature which was but two-tenths of a degree Centigrade lower than the average record of 49 years. Humidity and evaporation were also normal; the former was but 4.9 per cent lower and the latter 3.6 mm. short. Table 1 shows the weather condition for growth during the month of December, 1934, and January, February, and March 1935 as compared with their normal values.

SOIL

The soil is a typical sandy clay loam. It reveals no distinct soil profile; hence, it is an immature soil. The 12-inch surface consists of pale brown sandy clay loam in the first 6 inches, loose and friable in the upper 2 to 3 inches, and becoming nearly compact in the deeper layers. It is granular in structure. The second 6 inches is dark brown sandy clay loam with mixture

[1] Meteorological data were furnished by the Weather Bureau, Manila.

TABLE 1.—*Meteorological data in Manila during the month of December 1934, and January, February, and March of 1935 as compared with their normal values.*[1]

Elements	December		January	
	1934	Normal	1935	Normal
Mean temperature—centigrade	24.9	25.0	24.2	24.7
Average humidity—percentage	78.7	81.1	74.8	77.8
Amount of rain—mm	37.7	59.9	2.3	24.2
Number of rainy days	12	9	5	5
Total evaporation—free exposure (Piche tube)—mm	86.8	87.9	114.3	99.0

Elements	February		March		Length of period
	1935	Normal	1935	Normal	
Mean temperature—centigrade	25.7	25.3	26.8	26.6	1885–1934
Average humidity—percentage	76.0	73.8	69.6	71.3	1885–1934
Amount of rain—mm	39.3	11.4	51.6	17.5	1865–1934
Number of rainy days	7	3	2	3	1865–1934
Total evaporation—free exposure (Piche tube)—mm	119.4	135.9	178.0	179.3	1910–1934

[1] Meteorological data were obtained from Manila Central Observatory of the Weather Bureau, Manila.

of very dark brown clay carried down by percolating water through the root-holes of previous plants. Although this 6-inch layer of soil is nearly compact, yet it is friable and granular in structure. The soil at the third 6-inch layer is brown sandy clay mixed with dark brown clay carried down by percolating water. It is friable to nearly compact in consistency and slightly granular in structure. At two feet level the soil is mottled reddish brown and gritty sandy clay. It is slightly granular to nearly structureless and nearly compact. When moist, the soil is easily excavated since it contains enough sand to give it a good structure.

The hygroscopic coefficient[2] of the 6-inch surface was 7.03 per cent; that of the 6- to 12-inch depth, 6.27. Those of the third- and fourth-inch levels were 7.05 and 7.82 per cent respectively. The 6-inch surface layer was acidic, pH 5.9 and that of the 6- to 12-inch depth slightly less so, pH 6.18. The third and fourth 6-inch layers gave pH value of 6.23 and 6.76, respectively. Acidity decreased with depth.

[2] Hygroscopic coefficient, moisture contents, and pH value were determined by the soil technologist of the Bureau of Plant Industry, Manila.

METHOD AND PROCEDURE

Well pulverized and sterilized garden soil was brought to optimum moisture content and placed in seed boxes, 12 cm. deep, 40 cm. wide and 50 cm. long. Tobacco seeds of the Ilagan Sumatra variety were sown sparingly in the soil contained in the seed box on September 20, 1934. Four days later, the seeds germinated. From this time up to the time of pricking or transplanting the young seedlings to another seed-bed, the boxes were exposed to the morning sun daily for about 2 hours during the first two weeks, then brought again under a shade for the rest of the day. When the young tobacco seedlings had four developed leaves, they were pricked to another seed-bed, and allowed to remain there till they were transplanted to the field.

The seed-beds were 1 meter wide and 10 meters long. The soil was a typical garden loam. It was forked and reforked to about one foot deep. The soil was thoroughly pulverized. No weeds were allowed to grow. A ditch about one foot deep was dug around the seed-bed to insure good drainage.

Previous to pricking of the young tobacco seedlings, the seed-bed was watered late in the evening to about its optimum water content. Then the young plants were pricked the following day and spaced to about 10 cm. apart. The seed-bed was kept moist all the time. During the first two weeks after pricking, the seedlings were shaded with abaca cloth placed about $1\frac{1}{3}$ meters above the ground. The shade was inclined to about 25° facing East. After two weeks, the shade was removed, the plants were exposed to the sun till they were transplanted to the field previously plowed and harrowed several times when the stems of the tobacco seedlings were about 8 cm. high. They were planted in rows, 80 cm. between the rows and 50 cm. between the plants. Transplanting was done late in the afternoon.

The roots and top development of the tobacco plant were determined at various intervals during its life time. The root system was studied by following the direct-trench method described by Weaver(1). At each time of excavation the root systems of several plants, with tops of average size were exposed and measured. After several measurements, a typical plant (root and top) was selected and drawn to scale. The leaves were cut at the base of the petiole. The area of the leaves was ascertained by carefully flattening them on a piece of white paper and the margin traced, and area determined with a planimeter.

Determinations of total height, number of leaves, and number of roots of the first order (secondary roots) were taken when the plants had reached maturity. The height of the plant was measured from the surface of the ground to the tip of the inflorescence. Leaves arising from branches of the main stalk were not included in the counting. Roots arising only from the primary root or top roots are designated here as branch roots of the first order or secondary roots and those that arise from them are branch roots of the second order, or tertiary roots, etc.

Soil sampling for soil acidity, moisture content, and hygroscopic coefficient was done by digging a trench, and duplicate samples of soil of sufficient quantity were gathered at every 6-inch layer along the edge of the trench. Also the soil profile was taken. Each sample was brought to a constant weight and water content was based on the dry weight of the soil. Soil acidity was determined by the quinhydrone method. The hygroscopic coefficient was ascertained by the usual way.

For the sake of clarity, the development of roots and top of tobacco plant from seed to maturity, i. e., its life history is divided into three stages; namely, from sowing to pricking or seedling stage; from pricking to transplanting or nursery stage; and from transplanting to harvest or field stage.

LIFE HISTORY OF TOBACCO PLANT

The small seeds were sown in seed boxes on September 20. Numerous tiny roots began to come off the seed coat after four days.

DEVELOPMENT OF ROOTS AND TOP DURING THE SEEDLING STAGE

Four days after sowing the seeds, representative samples were dug and drawn to scale (Fig. 1–A). Although the shoot was not yet off the seed coat, the primary root, radicle, was already 2 mm. long. Four days later (September 28) the hypocotyl was already 2 mm. off the surface of the ground but the cotyledons were still unfolded (Fig. 1–B). At this stage of development the radicle was already 4 mm. long. It was about a millimeter in diameter, turgid, white, profusely covered with root hairs at a point 2 mm. back of the root tip, and had developed no branches.

Growth was so slow that within another four days, on October 2, the height of the hypocotyl was 3 mm. only. The two cotyledons were well expanded and each measured 3 mm.

long and 1 mm. wide. They were green and served as the first pair of false leaves. The root continued its downward movement and had penetrated the soil to a depth of 8 mm. (Fig. 1–C).

During the following period of four days, the tip of the first true leaf appeared (Fig. 1–D). The cotyledons expanded a little bit more now measured 4 mm. long and 2 mm. wide, but there was an apparent decrease in thickness. The hypocotyl had grown to 8 mm. long and the primary root had extended its growth very slowly to a depth of 10 mm.

After four more days of growth, 20 days from the date of germination (Fig. 1–E), the seedlings were 1.4 mm. high. The cotyledons had expanded a little more. The first true leaf produced measured 3 mm. long and 2 mm. wide and the tip of the second leaf had appeared. The root penetrated the soil to a depth of 1.8 cm. The growth of the plant as a whole was very slow.

Slow growth continued so that within a period of 6 days, on October 16, a height of 1.6 cm. had been attained. The shoot had two leaves, the longer leaf measured 8 mm. long and 3 mm. wide and the other was a half smaller. The tip of the cotyledons began to show sign of drying and now they were 6 mm. long and 3 mm. wide. The primary root was 2.2 cm. long and 2 branch roots of the first order secondary roots

FIG. 1. Seedlings of tobacco plant (seedling stage) at the ages of 4, 8, 12, 16, 20, 26, 35, and 40 days, respectively. The smallest was excavated on September 24 and the largest on October 30.

appeared for the first time, 22 days after germination. One of them came out just below the surface of the ground and the other at a depth of one-half centimeter. The root system had a total length of 2.9 cm. and that of the top had a total leaf area of 0.25 sq. cm. (Fig. 1–F).

During the following period of 9 days the shoot had unfolded the third leaf completely, the tip of the fourth leaf was over 2 mm. long, and had a leaf spread of about 2 cm. (Fig. 1–G). The top had a total leaf area of 1.5 sq. cm. The cotyledons were pale yellow with their margins shriveled. The primary root had penetrated the soil to a depth of 2.8 cm. A third secondary root came out and the first tertiary root, branch root of the second order, appeared 9 days later after the appearance of the first secondary root. At first, the branch roots of the first order ran out vertically downward to a depth of about one centimeter, then turned obliquely at an angle of about 45°. The total length of the root system was 6.4 cm. occupying a cylinder of soil 2.4 cm. in diameter and 2.8 cm. deep (Fig. 1–G).

When the plants were 40 days old, on October 30, the shoots had four well expanded leaves and the fifth leaf was 5 mm. long and 3 mm. wide (Fig. 1–H). The top had a spread of 3 cm. The leaf area was 4.3 sq. cm. The biggest leaf measured 2.4 cm. long and 1.3 wide. The cotyledons were yellow and partly dry. The epicotyl is now distinct and had a height of 4 mm. The primary root had made a little growth of 6 mm. in 5 days but instead 4 more secondary roots came out just a few millimeters below the surface of the ground. The length varied from a few millimeters to 2 cm. The root system had a total length of 9.6 cm.

DEVELOPMENT OF ROOTS AND TOP DURING THE NURSERY STAGE

Nursery stage is here designated to cover a period of the life of the tobacco plant from the time of pricking the young plantlets to another seed-bed till they are transplanted to the field. Proper precautions was given to the seedlings in the process of lifting in order to cause the least disturbance of the parts below the ground. At the same time, the best of care, such as watering, weeding, and proper duration of shading, were given to them every day in order that the growth of the newly transplanted plants would continue unhampered.

The development of both top and roots were again studied 6 days later, on November 5, after pricking (Fig. 2). The leaves

already developed, when pricked, did not wilt, hence the atmospheric conditions for growth which prevailed during that time were favorable for the growth of the young plants. The cotyledons had dropped off. No new leaf had developed and the plants had an average total leaf area of 5.3 sq. cm. In spite of the extreme precaution resorted to during the time of pricking, the tip of the primary root was broken in the course of lifting (Fig. 2). However, the number of secondary roots increased from 7 to 11 and also branch roots of the second order appeared. This rapid growth happened within a period of 5 days. The length of the roots of the secondary root ranged from 0.5 to 4.2 cm. with a total length of 17.5 cm. Some of the roots ran rather horizontally outward, others obliquely downward, all into territory unoccupied by the primary root ramifying in a voulme of soil 4 cm. in diameter and 3.7 cm. deep. Most of the root tips were found within the first 2 cm. layer of soil.

After another 7-day period (November 12) of growth on the seed-bed the height of the stem averaged 1.2 cm. (Fig. 2.)

FIG. 2. Development of tobacco plant (after pricking-nursery stage) on Nov. 5, 12, 23, and Dec. 14. The smallest was 5 days old after pricking and the largest was 45 days old. The 2 plants at the middle were 14 and 24 days old, respectively. (Please see under illustration.)

The sixth leaf was appearing and the first and second leaves were beginning to turn yellow. The area of green leaves to a plant averaged 12.2 sq. cm. and the largest leaf measured 3.4 cm. long and 2.5 cm. wide with an average total leaf spread of 5.5 cm. The secondary root system consisted of 12 roots and their branches; the longest was 4.5 cm. Most of the secondary roots ran out obliquely at an angle of about 45° to a depth of almost 2 cm. and then turned somewhat vertically downward. The length of the root system increased from 17.5 to 37.7 cm. contained in a space of soil 5 cm. wide and 5.5 cm. deep.

After a period of 11 days, on November 23, the stem was 2 cm. high (Fig. 2). The first two leaves were dead and the third leaf was beginning to turn yellow. The tip of the seventh leaf had appeared. The total leaf area (green) was 22.9 sq. cm. with a leaf spread of 9 cm. The number of secondary roots increased from 12 to 16 and tertiary roots were abundantly produced ranging from a few millimeters to 1.5 cm. in length. The bulk of the absorbing surface ramified in the first 4-centimeter layer of soil occupying a volume of soil 8.5 cm. in diameter and 7.5 cm. in depth. The total length of the root system averaged 117.9 cm.

A final study of both top and roots of the plants during the nursery stage was made after 21 days interval, on December 14, when the tobacco seedlings were transplanted to the field. The stem had increased in height from 1.2 to 7.5 cm. The shoot had 11 developed leaves. The first 4 were dead and the fifth one was already yellow. The largest leaf measured 12.5 cm. long and 5.5 cm. wide. The total leaf area (green) was 115.8 sq. cm. and the leaf spread was 20 cm. long. The number of roots increased to 16 and the whole root system had grown very rapidly reaching a depth of 17.5 cm. with a lateral spread (both sides) of 14 cm. (Fig. 2). There were 108 tertiary roots developed and were evenly distributed from the surface of the ground to a depth of 16 cm. The root system completely ramified a volume of soil 14 cm. in diameter and 17.5 cm. deep with a total length of 437 cm.

DEVELOPMENT OF ROOTS AND TOP DURING THE FIELD STAGE

The young plants transplanted to the field on December 14 recovered rapidly, planting having been immediately followed by moderate rains. Determination of the water content in per cent in excess of the hygroscopic coefficient taken 6 days later,

on December 20, showed that the first 6-inch layer of soil contained 13.2 per cent water available for growth, that of the second 6-inch layer was 17.73. Those of the third and fourth 6-inch layers were 18.0 and 24.2 per cent, respectively. There was a total rainfall of 37.7 mm. for the month of December.

The following month, January, was rather dry having had only 2.3 mm. of rain. Although the surface soil was rather dry, the deeper soil was moist. Atmospheric conditions for growth were favorable for rapid growth (Table 1).

The plants were again examined after a period of 48 days, on January 31, after transplanting but at this time there were no drawings made. The stems averaged a meter high and had 18 leaves. The largest leaf was 30 cm. long and 20 cm. wide. There was a total leaf area (green) of 2,804 sq. cm. The root system had developed so rapidly that the secondary root system had 23 well developed roots ranging from 5 to 25 cm. long with 264 branch roots of the second order. At this stage of development, the bulk of the absorbing organ was found within the first 15-centimeter layer of soil ramifying in every direction and occupying a diameter of 28.7 cm. The root system had penetrated the soil to a depth of 21.2 cm.

Further determination of the water content of the soil was taken on February 28 when the tobacco plants were about to be in full bloom. There was a total rainfall of 41.6 mm. that fell since the last examination (Table 1). Notwithstanding the moderate rains, the rapid growth of the plant had reduced the available moisture content of the soil a great deal especially the first two 6-inch layers. That of the first level was from 13.2 to 6.97 per cent and that of the second layer was from 17.73 to 11.73 per cent. With the deeper layers, 12 to 18 and 18 to 24 inches, the moisture contents were 15.95 and 22.18 per cent, respectively. At this time the stems had an average height of 220 cm. with 30 leaves. The basal leaves were yellow and the standards were just at the right age for priming. The total area of the green leaves was approximately 7,300 sq. cm. The largest leaf measured 39 cm. long and 25 cm. wide. The root system had penetrated the soil to a depth of 50 cm. and the lateral roots covered a diameter of 45 cm. of soil with a working level at a depth of 30 cm. The secondary root system had increased considerably such that there were 454 tertiary roots and 38 secondary roots. The root system occupied a volume of soil 50 cm. deep and 45 cm. in diameter com-

pletely ramifying the whole space especially that of the first foot layer of soil.

A final study of both top and roots was made on March 31. The plants were now 107 days old from the date of transplanting the young seedlings to the field. There was 51.6 mm. of rains that fell during the month of March. In addition to this the plant still reduced the available moisture content of the soil for plant growth in the first 6-inch layer of from 6.97 to 6.67 per cent. There were slight increases in the second and third 6-inch layers but there was a decrease of about 1 per cent in the fourth layer. The plants had reached a height of 240 cm. The additional 20 cm. increase since the last examination was due to the increase in length of the stalk of the inflorescence. Five small leaves were added. Although there were more leaves at this time the area of green leaves was 404 sq. cm. smaller than its leaf area on February 28. This was due to the drying and yellowing of the older leaves which were not included in the determination of the total green area of the plant. At this time all the standard leaves were over-ripe for harvesting especially if they were for wrapper. The root system had reached a maximum depth of 60 cm. However, most of the root tips, the most important parts of the roots for absorption, were found at a depth of 35 cm. There was no apparent increase in the number of roots since the last examination. A mature tobacco plant occupied a cylinder of soil 50 cm. in diameter and 60 cm. deep.

DISCUSSION

A survey of these data shows that the growing period of the tobacco plant fell into three rather distinct stages, i. e., seedling stage, nursery stage, and field stage. These stages of the life of the plant exhibited different rates of growth.

The seedling stage was marked with exceedingly slow growth. The roots grew at the rate of 2.4 mm. a day during a period of 40 days, and the leaves for the same length of time grew 10.7 sq. mm. a day. The primary root had penetrated the soil to a maximum depth of 3.4 cm. This rate of growth is exceedingly small as compared with the growth rate of other annual crops like wheat during the seedling stage. The wheat plant, even after a period of 20 days only, had already developed a leaf area of 21.5 sq. cm. (3) (1 sq. cm. a day) and the primary root had a maximum penetration of 15.5 inches (38.7 cm.). This big

difference in the rates of growth of the two kinds of plants during the seedling stage is due to the amount of food reserved in the seed. Tobacco seeds are so minute that it takes about 20 seeds to weigh one milligram; hence the amount of food stored in a seed to support the young plant in its first stage of growth is extremely small. It soon consumes this small amount of reserve food and is forced to prepare its organic matter at a very much earlier stage than that of any other annual crop. The best of attention is therefore necessary in the case of the tobacco plants at this stage.

The growth rate of the tobacco plant during the nursery stage was marked with rapid production of roots and fast development of leaves. Within a period of 45 days the root system had grown at the rate of 9.7 cm. as compared with 2.4 mm. per day during the seedling stage. Secondary roots were coming out at the rate of 1 root for every 5-day period and 2.4 tertiary roots daily during 45 days. At this time the root system occupied a depth of soil 17.5 cm. and 14 cm. wide. The total length of the root system increased from 9.6 cm. (seedling stage) to 4.37 meters or with an increase of 4452 per cent during a period of 45 days. This rapid growth of the underground parts of the tobacco plant was accompanied with rapid production of leaves but of lesser percentage increase, being only 2593 per cent. Leaves appeared at the rate of 1½ for every 10-day period with a growth rate of 2.5 sq. cm. a day as compared with 10.7 sq. mm. when the plants were at the seedling stage. Plate I is a graphic representation of the roots and top development of the tobacco plant from sowing to transplanting the young plant to the field. It is to be noted that at first both at the roots and at the top the growth rate was so slow that not until the root system had increased materially, that is, after pricking on October 30, did rapid leaf development occur, but synchronously more elaborate root system was developed toward the latter period of the nursery stage. It was at this time that the plants began to need ample supply of plant nutrient for growth.

After a period of 48 days in the field, the tobacco plants had reached a height of one meter. Some more leaves were produced and the leaves already developed had grown at the rate of 56.0 sq. cm. a day during a period of 48 days. At this time the shoot made rapid growth and exceeded in length the depth of root penetration. The general width of the root

system was blocked out after the first 48 days of growth in the field and its further development consisted in elongating, branching, and the addition of new roots.

During the next 28 days the plants were almost in full bloom and had attained a height of 2.2 meters. The standard leaves were now at the right age of harvesting. The plant had a total leaf area (green) of 7,300 sq. cm. or an increase of 160 per cent during a period of 28 days. The leaves had grown at the rate of 160.5 sq. cm. a day. Root penetration reached a depth of 50 cm. More secondary roots were added at the rate of 5.3 for every 10 days and they were densely clothed with branches. The bulk of the absorbing organ was found in the first foot layer of soil although some had extended to a depth of 50 cm.

A mature plant occupied a cylinder of soil 50 cm. in diameter and about 2 feet deep. The secondary root system had 40 main roots with numerous branch roots varying in length from a few millimeters to 5 cm. The height of the plant at maturity was a little over 2 meters. The entire development had taken place within 6 months.

Tobacco at first is a slow grower; but after the seedling stage, rapid growth of both top and roots sets in and reaches its maximum development after about two months in the field.

Tobacco is a surface feeder as evidenced by the depth of root penetration. The lateral roots are confined within a short radius. Because of this growth behavior, tobacco, especially of the wrapper type, requires a region with a good precipitation during its vegetative development and soil which is fertile. It is not surprising to see that after the fourth crop is obtained from the same field the produce becomes very poor since the plant has a big-sized and very efficient root system absorbing nutrients from a small volume of soil. A noteworthy yield of tobacco can only be realized from the same field provided the soil is supplied with the necessary plant food artificially.

SUMMARY

Tobacco of the wrapper type was grown on level, fertile, sandy clay loam at Malate, Manila during the growing season of 1934–1935. Its root and top development had been studied at various intervals and drawings of representative samples had been made. Seeds were sown sparingly in seed boxes on September 20; development was so slow that during 40 days

of the seedling stage, the roots had grown at an average rate of 2.4 mm. per day and the shoot developed 5 small leaves only.

During a period of 45 days of the nursery stage, the roots had grown 9.7 cm. a day and the longest root had reached a depth of 17.5 cm. The shoot had produced 11 leaves. The rate of leaf growth averaged 2.5 sq. cm. per day. At this time the rate of growth of the roots had exceeded that of the top, the leaves.

A height of one meter and a root depth of 21.2 cm. with a lateral spread of 28.7 cm. were attained during the following 48 days after transplanting the young tobacco plants in the field. There was also an increase of 2321 per cent of leaf area. It is at this stage of development that the tobacco plant is badly in need of food supply. The general width of the root system was blocked out and its further growth consisted in the elongation and production of new roots.

A month later, the plant reached its maximum development with a total leaf area of 7,300 sq. cm. The rate of leaf growth was 160.5 sq. cm. a day. This rapid development of top growth was supported by a root system occupying a cylinder of soil 45 cm. wide and 50 cm. deep. It consisted of 38 secondary roots and hundreds of tertiary roots of varying length, from a few mm. to 5 cm.

The height of mature plants varied from 200 to 240 cm. The maximum area of green leaves was 7,300 sq. cm. each plant. There were 35 leaves produced, the biggest measured 39 cm. long and 25 cm. wide. Root penetration had reached a depth of 60 cm. and the lateral roots covered a radius of 25 cm. The root system consisted of 40 main secondary roots and numerous tertiary roots with their branches clothed with root hairs. The bulk of the absorbing organ for water and nutrient ramified within the first foot level and only a few had reached a depth of 50 cm. At first the secondary root system branched out obliquely from the primary root at an angle of about 45° to a depth of 20 cm., then turned its direction vertically downward.

The tobacco plant is a heavy consumer both of water and nutrient because of its great leaf area resulting from the production of an elaborated root system. Repeated determination of the position, extent, and depth of root penetration of this plant shows that it is a surface feeder; hence cultivation in the field to a depth of 20 cm., especially if operation is done

close to the plant, is detrimental to the growth of the root system. The proper type of cultivation is deep enough to kill the weeds but shallow enough to reduce root injury to the minimum. Unless irrigation is supplied in time of need, wrapper tobacco should not be grown in regions where moderate rainfall does not fall often in a month during its rapid vegetative development. A tobacco plant matures completely within 6 months.

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ILLUSTRATIONS

PLATE 1

Relative rate of growth of both roots and top of tobacco plant from date of sowing, September 20, to date of transplanting to the field on December 14.

TEXT FIGURES

FIG. 1. Seedlings of tobacco plant (seedling stage) at the ages of 4, 8, 12, 16, 20, 26, 35, and 40 days, respectively. The smallest was excavated on September 24 and the largest on October 30.

2. Development of tobacco plant (after pricking—nursery stage) on November 5, 12, 23, and December 14. The smallest was 5 days old after pricking and the largest was 45 days old. The two plants at the middle were 14 and 24 days old, respectively.

PLATE 1.

A PROGRESS REPORT ON THE EFFECTS OF NITROPHOSKA FERTILIZER ON OLD BATANGAS MANDARIN ORCHARDS

By Juan P. Torres
Of the Bureau of Plant Industry

TWO TEXT FIGURES

This paper presents the progress of nitrophoska fertilizer experiment on old Batangas mandarin which was conducted in the barrio of San Vicente, Santo Tomas, Province of Batangas, with Menzi & Co., Manila, furnishing the fertilizer used. The data presented in this article consist of the results of three consecutive years' tests, 1933 to 1935, inclusive.

MATERIALS USED

The nitrophoska is a "complete" fertilizer containing 52.5 per cent of fertilizing elements comprising 15 per cent nitrogen, 11 per cent water soluble acid phosphate, and 26.5 per cent soluble potash.

The experiment was performed in the orchards belonging to Mr. Atanacio T. Carandang, of the Calamba Sugar Estate, Canlubang, Laguna; but in order to try somewhat varying conditions of trees the test had been extended to the plantation of Mrs. A. P. Torres, which is located about a half kilomenter south of Mr. Carandang's orchard. For convenience, Mr. Carandang's orchard is here designated as A. T. C. orchard and Mrs. Torres' as A. P. T. orchard.

For dressing the large wounds after pruning, Napoleon green paint, red paint and asphalt mixed with linseed oil in the proportion of 2 to 1 part by weight were used, and for treating bark rot disease, coal tar and carbolineum were used.

PREVIOUS HISTORY OF ORCHARD AND TREATMENT

The trees in both orchards were about 25 years old when the experiment was started. In A. T. C. orchard the trees were entirely neglected prior to 1923, and it was then decided to

clean up the orchard of bananas, wild trees, shrubs and grasses. That orchard was plowed lightly and hoe-cultivated and planted to rice, corn, and vegetables for five consecutive years. From late 1928 the orchard was allowed to remain under grass-sod until the fertilizer test was started.

The A. P. T. orchard was repeatedly plowed, cultivated and planted to rice and corn for many years before the experiment. The trees had received merciless rough-and-tough treatment. Deep plowing close to the trunks evidently had pruned the root system very badly, thus affecting the trees very severely. Many

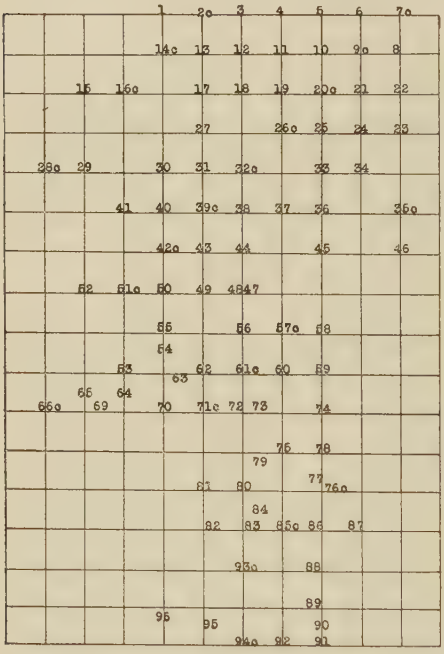

Fig. 1. Diagrammatic planting plan of A. T. C. Orchard No. 1

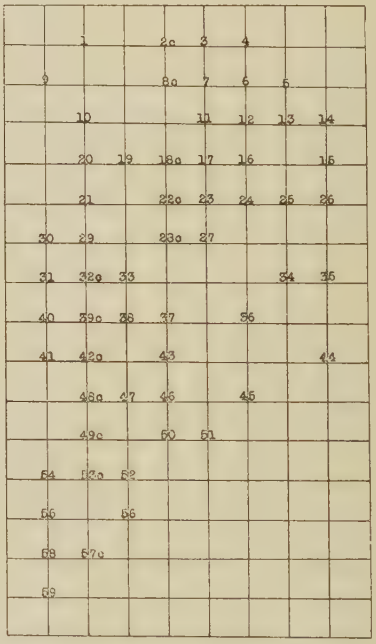

Fig. 2. Diagrammatic planting plan of A. P. T. Ochard No. 2

of the branches of a tree died that in many cases the entire tree died out. The remaining trees and branches appeared very unhealthy at the time of the first fertilizer application. Due to change of ownership in January, 1933 the treatment of the orchard was also changed. The orchard was plowed just once and far enough from the trees and then planted to ipil-ipil, *Leucaena glauca*, for permanent cover crop.

Just before the fertilizer was applied the trees in both orchards were carefully pruned. All dead and unnecessary branches and twigs had been removed together with the *Loran-*

thus which was pestering on the trees quite severely. Some of the cuts, owing to the removal of the branches, were dressed with Napoleon green paint, some with red paint, while the others were dressed with asphalt-linseed oil preparation. The kind of soil in both orchards is light and more or less porous loam which is the general type of soil found in citrus orchards in Batangas.

EXPERIMENT AND RESULTS

When the experiment was started in February, 1933 there were 130 trees in A. T. C. orchard and 59 trees in A. P. T. orchard. All the trees were numbered individually. After a careful study of the suitability of individual trees for the test was made the number of trees for experiment in A. T. C. orchard had been reduced to 92 trees. The first application was made on February 2 and 3, 1933, the second on January 15 and 16, 1934, and the third in January, 1935. In the 1933 application the fertilized trees in A. T. C. orchard received 2 kilograms of Nitrophoska fertilizer each and those in A. P. T. orchard 1.5 kilograms each. (See planting plans Nos. 1 and 2. Those marked with (*c*) are check or untreated trees.)

In 1934, two quantities of the fertilizer were tried in A. T. C. orchard. Fertilized trees, in A. T. C., Nos. 1 to 52 received 3 kilograms each and the rest of the treated trees, including the fertilized trees in A. P. T. orchard, were supplied each with 2 kilograms. The trees in A. P. T. orchard were pruned again of dead and unnecessary twigs and small branches in April and May, 1934. In May and June, 1934 the trees in both orchards were treated for bark-rot disease. In January, 1935 the same rates of fertilizer as those in the preceding years were applied.

The fruit yields and condition of individual trees in A. T. C. orchard are shown in Table 1 and those in A. P. T. orchard are presented in Table 2. The number, percentages and the average production of bearing trees for three years are given in Table 3.

The condition of tree refers to the relative health of trees as they appear at the time of observation, and is graded from 1 to 5. The figure 5 refers to the normal condition of the tree having a dense and deep green foliage; 4 denotes a less dense but green foliage with least amount of dead twigs; 3 signifies light green foliage with noticeable quantity of dead twigs; 2 indicates very light green scanty foliage with considerable

TABLE 1.—*Yields of individual trees in A. T. C. orchard in 1933, 1934, and 1935*

Tree number	Fruits			Condition	Tree number	Fruits			Condition
	1933	1934	1935			1933	1934	1935	
A. T. C. 1	13	203	268	3	A. T. C. 49	46	130	128	5
A. T. C. 3	25	305	52	4	A. T. C. 50	0	0	45	5
A. T. C. 4	8	210	36	4	A. T. C. 51c	0	0	1	5
A. T. C. 5	52	205	65	5	A. T. C. 52	0	0	0	4
A. T. C. 6	7	25	72	5	A. T. C. 53	0	83	8	5
A. T. C. 7c	22	75	66	4	A. T. C. 54	20	100	18	4
A. T. C. 8	5	1	12	4	A. T. C. 55	35	0	5	5
A. T. C. 9c	15	115	32	4	A. T. C. 56	219	301	60	3
A. T. C. 10	72	505	108	4	A. T. C. 57c	179	220	24	5
A. T. C. 11	23	305	120	4	A. T. C. 58	9	293	22	5
A. T. C. 12	22	285	162	5	A. T. C. 59	155	88	7	5
A. T. C. 13	18	258	42	5	A. T. C. 60	203	215	35	5
A. T. C. 14c	5	141	12	5	A. T. C. 61c	139	210	64	4
A. T. C. 15	12	15	102	4	A. T. C. 62	154	200	160	3
A. T. C. 16c	0	85	66	4	A. T. C. 63	8	35	37	5
A. T. C. 17	28	475	9	4	A. T. C. 64	0	0	15	5
A. T. C. 18	176	441	(*)	(a)	A. T. C. 65	0	0	0	5
A. T. C. 19	131	585	14	3	A. T. C. 66c	0	0	(*)	(a)
A. T. C. 20c	30	340	(*)	(a)	A. T. C. 69	0	0	(*)	(a)
A. T. C. 21	183	158	812	5	A. T. C. 70	0	10	16	5
A. T. C. 22	28	330	108	5	A. T. C. 71c	11	200	26	5
A. T. C. 23	41	234	(*)	(a)	A. T. C. 72	4	50	67	5
A. T. C. 24	17	224	888	5	A. T. C. 73	0	20	88	4
A. T. C. 25	62	429	53	2	A. T. C. 74	4	5	31	5
A. T. C. 26c	421	930	(*)	(a)	A. T. C. 75	102	275	12	5
A. T. C. 27	21	130	108	4	A. T. C. 76c	359	10	15	5
A. T. C. 28c	0	0	0	(b)	A. T. C. 77	774	100	42	5
A. T. C. 29	0	2	0	(b)	A. T. C. 78	227	250	49	5
A. T. C. 30	0	50	41	1	A. T. C. 79	47	138	195	5
A. T. C. 32c	502	307	7	5	A. T. C. 80	12	40	126	5
A. T. C. 33	116	704	0	1	A. T. C. 81	18	3	78	5
A. T. C. 34	27	350	275	5	A. T. C. 82	9	10	233	4
A. T. C. 35c	41	80	0	5	A. T. C. 83	109	85	52	5
A. T. C. 36	32	150	180	5	A. T. C. 84	134	95	80	4
A. T. C. 37	55	375	0	5	A. T. C. 85c	72	85	4	5
A. T. C. 38	27	162	123	3	A. T. C. 86	405	20	21	5
A. T. C. 39c	0	210	5	3	A. T. C. 87	305	10	31	5
A. T. C. 40	0	4	95	5	A. T. C. 88	313	285	7	5
A. T. C. 41	0	0	0	4	A. T. C. 89	29	40	210	4
A. T. C. 42c	4	20	0	4	A. T. C. 90	31	40	90	5
A. T. C. 43	52	50	44	3	A. T. C. 91	7	25	268	5
A. T. C. 44	120	260	27	3	A. T. C. 92	76	0	3	5
A. T. C. 45	26	243	25	4	A. T. C. 93c	106	0	(*)	(a)
A. T. C. 46	42	20	135	5	A. T. C. 94c	1	0	74	5
A. T. C. 47	94	25	178	5	A. T. C. 95	0	0	0	(b)
A. T. C. 48	38	225	172	5	A. T. C. 96	0	0	0	(b)

* Dead trees during the year. [a] Dead. [b] Shaded.

TABLE 2.—*Yields of individual trees in A. P. T. orchard in 1934 and 1935*

Tree number	Fruits		Condition	Tree number	Fruits		Condition
	1934	1935			1934	1935	
A. P. T. 1	51	12	4	A. P. T. 31	0	0	4
A. P. T. 2c	288	0	5	A. P. T. 32c	0	(*)	(a)
A. P. T. 3	30	36	5	A. P. T. 33	1	12	5
A. P. T. 4	37	56	4	A. P. T. 34	(*)		(a)
A. P. T. 5	0	0	3	A. P. T. 35	0	0	4
A. P. T. 6	33	42	5	A. P. T. 36	0	0	5
A. P. T. 7	282	52	4	A. P. T. 37	0	0	5
A. P. T. 8c	287	20	4	A. P. T. 38	0	0	1
A. P. T. 9	0	26	5	A. P. T. 39c	0	0	4
A. P. T. 10	25	72	4	A. P. T. 40	3	22	4
A. P. T. 11	33	50	4	A. P. T. 41	0	0	1
A. P. T. 12	0	45	5	A. P. T. 42c	0	0	5
A. P. T. 13	5	22	5	A. P. T. 43	0	0	5
A. P. T. 14	0	0	5	A. P. T. 44	150	125	5
A. P. T. 15	0	5	5	A. P. T. 45	0	(*)	(a)
A. P. T. 16	0	0	5	A. P. T. 46	0	0	4
A. P. T. 17	0	0	5	A. P. T. 47	0	0	4
A. P. T. 18c	127	(*)	(a)	A. P. T. 48c	0	0	4
A. P. T. 19	28	36	3	A. P. T. 49c	0	0	4
A. P. T. 20	20	100	3	A. P. T. 50	0	0	4
A. P. T. 21	68	65	4	A. P. T. 51	0	0	4
A. P. T. 22c	44	0	2	A. P. T. 52	0	0	3
A. P. T. 23	0	(*)	(a)	A. P. T. 53c	0	0	4
A. P. T. 24	46	15	4	A. P. T. 54	0	0	4
A. P. T. 25	4	52	5	A. P. T. 55	3	0	4
A. P. T. 26	0	16	5	A. P. T. 56	3	12	2
A. P. T. 27	0	0	5	A. P. T. 57c	18	0	3
A. P. T. 28c	8	0	2	A. P. T. 58	0	0	4
A. P. T. 29	38	82	5	A. P. T. 59	0	0	4
A. P. T. 30	101	142	5				

* Dead trees during the year. [a] Dead.

amount of dead twigs and a number of small dead branches, and 1 denotes the lowest state of health or almost dying condition of the tree with yellowing foliage and some large dead branches. The condition of trees was observed on November 30, 1935 when most of the trees were bearing fruits.

In the 1932 fruiting season, before the test, out of the 92 trees in A. T. C. orchard 22 trees or 23.9 per cent bore fruit while in A. P. T. orchard none of the trees bore fruit.

1933 RESULTS

Out of 20 check trees in A. T. C. orchard 15 trees or 75 per cent fruited, and out of 72 treated trees there were 59 trees or

81.94 per cent bearing fruit. The average production for bearing trees was 127.1 fruits for the check, or 90 fruits for total check trees, as against 85.8 fruits for the bearing treated trees, or 70.3 fruits for total treated trees. It is evident that the percentage of bearing trees has been increased by fertilizer treatment but the average production was not. Such inconsistency of the results may be attributed either to the number of trees and the variation in the productive ability of individual trees comprising the two groups, or to the fertilizer treatment which as yet had not influenced the trees beyond the vegetative improvement.

TABLE 3.—*Results of nitrophoska fertilizer experiment with old Batangas mandarin in A. T. C. and A. P. T. orchards 1933, 1934 and 1935*

Treatment	Total trees	Bearing trees		Total production (fruits)	Average yield in fruits	
		No.	Per cent		Bearing trees	Total trees
(A. T. C. 1933):						
Control	20	15	75.00	1,900	127.1	90.0
2-kilo rate	72	59	81.94	5,061	85.8	70.3
(A. T. C. 1934):						
Control	20	15	75.00	2,943	196.2	148.1
2-kilo rate	34	28	82.35	2,816	100.6	82.8
3-kilo rate	38	36	94.22	8,153	226.5	214.6
(A. P. T. 1934):						
Control	12	6	50.00	772	128.7	64.3
2-kilo rate	47 (*1)	21	44.68	1,041	49.6	22.2
(A. T. C. 1935):						
Control	20 (*4)	13	65.00	396	30.5	19.8
2-kilo rate	34 (*1)	30	88.23	2,065	60.9	60.7
3-kilo rate	38 (*2)	31	81.58	4,499	145.1	118.4
(A. P. T. 1935):						
Control	12 (*2)	1	8.33	20	20.0	1.7
2-kilo rate	46 (*2)	23	50.00	1,097	47.7	23.8

* Number of trees died during the year.

Although none of the trees in A. P. T. orchard produced a crop during the same season, many of the treated trees afterwards improved in their condition. The leaves became darker green and the foliage became denser. Failure of the trees in this orchard to produce a crop was probably due to the poor condition of the trees when the experiment was started for the reason that they were not well cared for in previous years.

1934 RESULTS

The weather during this season was more favorable to citrus fruit production in Batangas than the weather during the pre-

ceding two years. The warm weather began early in January, and the rainy season started in May with a good amount of rainfall during the first week of April. The regular blooming period occurred during the second and third week of April.

Out of 20 control trees in A. T. C. orchard, 15 trees, or 75 per cent, were bearing; of the 34 trees each treated with 2 kilograms of the fertilizer, 28 trees, or 82.35 per cent, produced crops; and out of the 38 trees each supplied with 3 kilograms of the fertilizer, 36 trees, or 94.22 per cent, were bearing. The average yield of bearing trees was 196.2 fruits for the control, or 148.1 fruits for total check trees; 100.6 fruits for bearing trees treated with 2-kilo rate or 82.8 fruits for total trees; and 226.5 fruits for bearing trees each treated with 3-kilo rate or 214.6 fruits for total trees in the group.

From these data the treated trees apparently had greater per cent of fruiting than the control; nevertheless, the average production was not influenced by the application of 2 kilograms of the fertilizer per tree. The 3-kilo rate gave a higher average production showing about 44.4 per cent increase over the control.

The A. P. T. orchard showed 50 per cent bearing for the control lot and 44.68 per cent for the treated, with 2-kilo rate. The average production of bearing trees was 128.7 fruits for the control and 49.6 fruits for the fertilized. These data simply indicate that most of the trees in this orchard had not fully recovered from the effects of previous careless treatment. It may be stated that the condition of many of the trees after the second treatment showed still greater improvement.

1935 RESULTS

The trees had suffered from the effects of October and November, 1934 typhoons which not only destroyed the fruits entirely but also defoliated many of them. Inspite of the climatic conditions which were not favorable for citrus fruit production in this locality, as evidenced by the abnormally low average yields, the increase in yield due to fertilizer treatment seems more significant than any of the increase found in the preceding year.

It can be noted in Table 3 that the A. T. C. orchard gave 65 per cent bearing trees for the control; with the 2-kilo rate, 88.23 per cent of the trees were bearing; and with the 3-kilo rate, 81.58 per cent of the trees produced fruits. The average production of bearing trees was 30.5 fruits for the control; 60.9

fruits for the 2-kilo rate; and 145.1 fruits for the 3-kilo rate. Considering the total trees under each group the average production was 19.8 fruits for the control, 60.7 fruits for the 2-kilo rate, and 118.4 fruits for the 3-kilo rate.

In A. P. T. orchard there was one bearing tree out of 12 check trees. This represents 8.33 per cent bearing, whereas among the 46 treated trees there were 23 trees or 50 per cent bearing. The single check bearing tree produced 20 fruits, thus giving an average of 1.7 fruits for 12 check trees, whereas the 23 bearing trees gave an average production of 47.7 fruits or an average yield of 23.8 fruits for the treated trees.

GENERAL DISCUSSION OF RESULTS

In a previous report(1) it was known that a Batangas mandarin orchard with trees grown from seedlings, not budded, should show at least 80 per cent bearing trees in order to be considered normal with respect to this character. Hence, on the basis of this hypothesis, A. P. T. orchard may be considered on the whole still in the abnormal state although the treated trees have been supplied with 1.5 to 2 kilograms of nitrophoska each year for three consecutive years. This condition has been attributed to the very poor health of trees at the beginning of the experiment. On the other hand Table 3, shows that right after the first treatment the lot in A. T. C. orchard treated with fertilizer became normal as to bearing percentages and continued to be so year after year.

In the same report mentioned above[1] it is stated that with Batangas mandarin at bearing age, an average yield of 100 fruits or less is a *poor crop*, those ranging from 101 to 250 are fair crops and those from 251 or more are considered *good crops*. It is therefore evident that the crops from A. T. C. orchard in 1934, the check and the treated trees included, may be considered fair as well as the average yield of check trees in 1933, and the yield of the treated trees in the same year as almost so. But surely in 1935 all the average production of the control trees and that of those treated with 2-kilo rate are far below normal. Despite these low yields the increase in yield due to fertilizer treatment over the control seem worthy of further consideration. According to estimated cost of fertilization and value of production for 100 trees, as shown in Table 4, the

[1] Torres, J. P. and F. Marajas. Efficiency of citrus orchards in Tanauan Citrus Station. Phil. Agri. Journ. 6 (1935), pp. 195–216.

TABLE 4.—*Estimated profit per hundred trees using 2-kilo and 3-kilo rates of nitrophoska per tree (after the third application) in A. T. C. orchard.*

Treatment	Yield per 100 trees	Increase yield	Value of increase yield [a]	Fertilizer cost [b]	Profit per 100 trees
	fruits	*fruits*	*pesos*	*pesos*	*pesos*
Control	1,980				
2-kilo rate	6,070	4,090	40.90	34.10	6.80
3-kilo rate	11,840	9,860	98.60	52.15	46.45

[a] Average market price was ₱1 per hundred fruits.
[b] Cost of fertilizer was ₱16 per sack of 100 kilograms.
Cost of transportation of fertilizer was ₱0.50 for 200 kilograms.
Cost of applying fertilizer was ₱0.16 per tree.

TABLE 5.—*The condition of trees in two orchards on November 30, 1935*

Condition of trees	A. T. C. orchard						A. P. T. orchard			
	Check		2-kilo rate		3-kilo rate		Check		2-kilo rate	
	No.	Per cent	No.	Per cent	No.	Per cent	No.	Per cent	No.	Per cent
Dead	4	20.0	1	2.9	2	5.3	2	16.6	3	6.4
1	0	0	0	0	2	5.3	0	0	2	4.3
2	0	0	0	0	1	2.6	2	16.7	1	2.1
3	1	5.0	2	5.9	5	13.1	1	8.3	4	8.5
4	6	30.0	5	14.7	11	28.9	5	41.7	18	38.3
5	9	45.0	26	76.5	17	44.8	2	16.7	19	40.4
Total	20	100.0	34	100.0	38	100.0	12	100.0	47	100.0

TABLE 6.—*Showing the relation between yields and grade condition of trees for 1935*

Grade	Total trees	Non-bearing trees		Bearing trees		Total yield	Average yields	
		No.	Per cent	No.	Per cent		Bearing trees	Total trees
						fruits	*fruits*	*fruits*
1	4	3	75.0	1	25.0	41	25.00	10.25
2	4	2	50.0	2	50.0	65	32.50	16.25
3	13	3	25.0	10	75.0	837	83.70	64.39
4	45	18	40.0	27	60.0	1,793	70.11	39.84
5	73	15	20.5	58	79.5	5,342	92.10	73.18

profit was ₱6.80 for the 2-kilo rate and ₱46.45 for the 3-kilo rate. With a more favorable climate for citrus fruit production perhaps this gain would have been much larger.

In Table 5 it can be seen that more dead trees, in proportion to the living trees, were found among the check trees than the treated trees.

The check lots in two orchards gave 20 per cent and 16.7 per cent dead trees, whereas the treated showed from 2.9 per cent to 6.4 per cent dead trees. That is rationally to be expected for the check trees had received no other treatment except pruning, weeding, and treatment of minor diseases which, of course, are given all trees as uniformly as possible.

Now, considering that the trees having grades of 4 and 5 in condition are in normal state of health for fruit production, therefore it can be stated as shown in Table 5, that the control lot in A. T. C. orchard was 75 per cent normal; the lot treated with the 2-kilo rate was 91.2 per cent normal; and that with the 3-kilo rate was 73.7 per cent normal. In A. P. T. orchard the control was 58.4 per cent normal whereas in the lot with the 2-kilo rate there was 78.7 per cent normal trees. Owing partly to the heavy production in 1934 and partly to the effects of typhoons in the same year, many trees in the lot with the 3-kilo rate had been lowered in grades for 1935; nevertheless, they showed higher average production than either the check trees or those with 2-kilo treatment. It must be understood that the health grades of trees do not necessarily show direct relation to the actual yields at the time when the health condition was observed, for there are many trees loaded with more fruits yet lower in grades than the ones of better condition. By examining Table 6 this statement may be made more apparent. An old experience with Batangas mandarin is that the health condition of trees has much to do for fruit production in the following season.

We have just considered the results of nitrophoska fertilizer treatment using 2-kilo and 3-kilo rates per tree, and, in brief, it may be stated that the application of the fertilizer had increased the percentages of bearing trees as well as the general condition of the orchard, but the production of fruits had been influenced after the third application, though not in a very marked degree. The 3-kilo rate as compared with the 2-kilo rate of the fertilizer per tree, seemed to have more immediate effect upon yields in that a greater increase was obtained. However, no definite conclusion could be drawn from the data presented although they are sufficient to give some guide to similar undertaking in the future.

The condition of the trees should be considered before the fertilizer is applied. Obviously trees that are abnormally low in health condition with grades of 1 to 3 would not respond to fertilizer treatment as quickly as the ones with grades of 4 and 5, and it is but natural to expect a greater increase in yields with trees of normal health. Thus, we may now consider the points whereby an orchard could be judged as normal. A Batangas mandarin orchard may be said to be normal if it has at least 80 per cent bearing trees, its health condition being not less than 90 per cent normal and is producing a good crop on the average under a favorable climatic condition.

Rejuvenation of orchard specially needs a complete fertilizer as it improves the general condition of the trees. In these orchards under experiment it was observed that a greater number of vigorous shoots had been produced in the fertilized trees, which, in turn, had been top-worked with scions of some citrus varieties that are more productive than the old trees. After 2 or 3 years the top-works began to produce large number of fruits, thus increasing the productiveness of otherwise unproductive trees.

Of the three kinds used as dressing media the asphalt-linseed oil preparation proved the best. It showed quicker healing up and the wounds well covered with it are less subject to cracking and attack of various fungi. The coal tar as a control medium against the bark-rot proved harmful to surrounding healthy tissue, and often when the attack is quite severe the application of coal tar had caused rapid death of the entire branch. Carbolineum seemed less toxic to healthy tissue when applied in the same way.

SUMMARY

The results of nitrophoska fertilizer test with old Batangas mandarin trees for three consecutive years, 1933 to 1935 inclusive, are presented.

With an application of 2 kilograms of nitrophoska per tree per year the reaction seemed to take place after the third treatment. The 3-kilo rate has given earlier effect and larger increase in yield than the 2-kilo rate. With the 1935 crop there was a net profit of ₱6.80 for 2-kilo rate as against ₱46.45 for 3-kilo rate.

The application of nitrophoska fertilizer had improved the general condition and increased the percentage of bearing trees

of the orchards; nevertheless, the average increase in yield was not very substantial. The nitrophoska proved to be an effective fertilizer for rejuvenating old Batangas mandarin trees where the vigorous shoots from the tree-trunks are intended for top-working.

It was found out that, as regards increasing the yields, the trees of very poor condition do not react to the fertilizer treatment as quickly as the normal ones.

TABLE 7.—*Distribution of trees for yield classes*

Treatment	Number of fruits								Dead trees	Total trees
	Zero		1 to 100		101 to 250		251 or more			
(1933)	*Trees*	*Per cent*	*Trees*	*Per cent*	*Trees*	*Per cent*	*Trees*	*Per cent*		
Control	5	25.00	9	45.00	3	15.00	3	15.00		20
2-kilo rate	14	19.44	41	56.94	13	18.06	4	5.56		72
(1934)										
Control	5	25.00	6	30.00	6	30.00	3	15.00		20
2-kilo rate	7	20.59	19	55.88	4	11.77	4	11.77		34
3-kilo rate	3	7.89	9	23.68	12	31.58	14	36.85		38
(1935)										
Control	3	15.00	13	65.00					4	20
2-kilo rate	3	7.89	24	72.35	5	14.71	1	2.94	1	34
3-kilo rate	5	13.16	15	39.48	12	31.58	4	10.53	2	38

ILLUSTRATION

TEXT FIGURES

FIG. 1. Diagrammatic planting plan of A. T. C. orchard No. 1.
FIG. 2. Diagrammatic planting plan of A. P. T. orchard No. 2.

SOME NOTES ON AVOCADO FLOWER

By Juan P. Torres

Of the Bureau of Plant Industry

In the United States, Hawaii, the Philippines and elsewhere, rather extensive studies have been made on avocado with respect to varietal and botanical descriptions and classifications, propagation, cultivation, fertilization, and bud-and plant-selection. A few of these studies are the work of Popenoe(1) and (2); Pope(3); Wester(4); de Leon and Padolina(5); and Ryerson et al.,(6). But as regards the behavior of avocado flowers very few reports have been published. Ryerson(6) summarized the work of Stout(7) in southern California, and Robinson(8) has presented an interesting paper on pollen sterility in avocado. Avocado is very well adapted to this country. Its fruit is becoming popular, so any information which might help to increase fruit production should be welcomed.

This paper deals with some results of observation in 1931 on the flower behavior of some avocado varieties in Lamao Experiment Station, Limay, Bataan, together with some information on the technique of hybridization.

EXPERIMENTS AND RESULTS

Experiment No. 1.—In the study of flower movements, opening and closing, the varieties Wester, Tertoh, and Pollock were used. Each day for three consecutive days some fresh inflorescences were selected and the opening and closing of the flower were observed at half-hour intervals from 6 o'clock a. m. to 8 o'clock p. m. The morning flowers may be easily distinguished from the afternoon flowers in the same clusters by their difference in size. In the varieties with morning dehiscence the morning flowers are slightly larger than their respective afternoon flowers, and in the varieties with afternoon dehiscence the afternoon flowers are the larger. However, in order to facilitate further the identification of these two groups of flowers the morning flowers were marked with black India ink and the afternoon flowers with red ink.

The results of observation on the opening and closing of the flowers of the Wester, Tertoh, and Pollock varieties of avocado

are presented in Tables 1, 2, 3, 4, 5, and 6, and Table 7 shows the periods of opening and closing of both the morning and the afternoon flowers with the time of their maximum movements.

Experiment No. 2.—The varieties Commodore, Cyrus, Pollock, and Wester avocado were used in determining the time of dehiscence. In this study, the number of anthers bursting was counted at half-hour intervals. The observation on each variety was made in three consecutive days, each day from 7 o'clock to 12 o'clock noon on Cyrus and Pollock varieties, dislodging their pollen in the morning, and from 1 p. m. to 5 p. m. on Commodore and Wester varieties representing those having afternoon dehiscence.

The results of three days observation on Pollock variety are shown in Table 8 and those on Wester, Commodore and Cyrus varieties are presented in Tables 9, 10, and 11, respectively. The period of bursting of anthers and time of maximum dehiscence for each of the four varieties studied are given in Table 12.

Experiment No. 3.—The following crosses were attempted: Baldwin x Cyrus; Baldwin x Pollock; Commodore x Cyrus; Cyrus x Commodore; Cyrus x Wester; Miami x Wester; P. I. No. 4857 x Cyrus; P. I. No. 4857 x Wester; Pollock x Miami; Pollock x Wester; Tertoh x Wester; Wester x Cyrus; Wester x Miami; Wester x Pollock; and Wester x Tertoh. The object of crossing is to determine which varieties are cross-fertile and which are cross-sterile. The results are shown in Table 13.

Experiment No. 4.—The effect of self-pollination on the setting of fruits was studied in varieties Commodore, Cyrus, Miami and Pollock, and the natural pollination was observed in Pollock and Wester varieties. A number of flowers were hand-pollinated and in the case of natural pollination the total number of flowers was counted in each inflorescene. So as to minimize as much as possible cross-pollination due to insects, the clusters used in this test were located on the interior twigs of the tree, despite the fact that the clusters were left uncovered.

The results of self-pollination and observations on natural-pollination are presented in Table 14.

DISCUSSION OF RESULTS

1. OPENING AND CLOSING OF THE AVOCADO FLOWER

Wester.—The opening of 524 morning flowers of the Wester variety occurred from after 8 o'clock a. m. to about 11 o'clock a. m. with its maximum at 9:30 o'clock a. m. Their closing

commenced at 11 o'clock a. m. and lasted until about 2:30 o'clock p. m., with maximum closing at 1 o'clock p. m. At 11 o'clock a. m. the second group or the afternoon flowers (425 in number) began to open and continued so until about 3 o'clock p. m., with maximum at 12:30 o'clock p. m. It was noted however, that some flowers, a part of those which opened in the morning of the same day, opened, but without discharging their pollen, as late in the afternoon as from 4:30 o'clock p. m. to 6:30 o'clock p. m. The afternoon flowers closed from 5:30 o'clock p. m. until 7:30 o'clock p. m., with maximum at 6:30 o'clock p. m. It can be noted that in the Wester variety there is considered overlapping of the periods in which the two groups of flowers, morning and afternoon flowers, remained open. Because of this incident, overlapping, a greater chance of interpollination between flowers of the same tree is possible, which would result in more numerous fruit setting unless self incompatibility exists in the variety.

In this connection it must be mentioned that the morning flowers opened with receptive stigma but the pollen was not discharged and the afternoon flowers opened to discharge pollen. Based on the classification advanced by Stout(7) which was cited by Ryerson(6), the Wester variety belongs to Group A as regards flower behavior. In addition, it was also noted that the flowers that opened in the morning with receptive stigma, reopened to dislodge pollen in the afternoon of the following day.

Tertoh.—The morning flowers of the Tertoh variety which opened at about 6:30 o'clock a. m. and until 10:30 o'clock a. m., commenced to close at about 12 o'clock noon and continued until 1:30 o'clock p. m., with maximum opening at 7:30 o'clock a. m. and maximum closing at 12:30 o'clock p. m. The afternoon flowers of this variety, however, opened at about 3 o'clock p. m. to 5:30 o'clock p. m. and closed at about 6 o'clock p. m. to 7:30 p. m., the time for maximum opening was 3:30 o'clock p. m. and 6:30 o'clock p. m. for maximum closing. The dehiscence of pollen took place with the opening of the morning flowers. It is evident, therefore, that the movement of the Tertoh variety was opposite to that of the Wester and consequently the variety Tertoh belongs to Group B of avocados, according to Stout's classification of avocado varieties which was cited above.

One more point of interest in this connection is the fact that, being unlike the Wester variety, its two groups of flowers do not overlap in their periods of opening. Unless the stigma remains

TABLE 1.—*Opening and closing of the morning flowers of the Wester avocado*

Dates of observations	Number of clusters	Time of opening and closing and number of flowers													Total
		8:00	8:30	9:00	9:30	10:00	10:30	11:00	11:30	12:00	12:30	1:00	1:30	2:00	2:30	
February 25, 1931	5		53	101	35	2	12	–1	3	84	77	33	5	0	0	203
February 26, 1931	5			4	64	21	80	6–1	2	2	28	128	13	1	1	175
February 27, 1931	5			13	79	15	32	7	0	0	0	–57	53	29	7	146
Total	15		53	118	178	38	124	13–2	5	86	105	218	71	30	8	524

NOTE.—Beginning of the closing of the flower.

TABLE 2.—*Opening and closing of the afternoon flowers of the Wester avocado*

Dates of observations	Number of clusters	Time of opening and closing and number of flowers									
		10:30	11:00	11:30	12:00	12:30	1:00	1:30	2:00	2:30	3:00
February 25, 1931	5			8	74	34	7	1	0	0	0
February 26, 1931	5		2	0	65	81	12	1	4	5d	0
February 27, 1931	5				22	56	4	3	0	0	1
Total	15		2	8	161	171	23	5	4	5d	1

Dates of observations	Number of clusters	Time of opening and closing and number of flowers								
		3:30	4:00	4:30	5:00	5:30	6:00	6:30	7:00	7:30	Total
February 25, 1931	5	0	0	2	2	5–7	42	55	20	9	133
February 26, 1931	5	0	0	0	7	11	5–28	3–93	43	22	181
February 27, 1931	5	0	2d	0	0	12	2–17	1–59	14	9	101
Total	15	0	2d	2	9	28–7	7–87	4–207	77	40	425

d=dropped.

6–7 means 5 flowers opened and 7 flowers closed at 5:30 p. m.
The first (–) represents the beginning of the closing of the flowers.

TABLE 3.—*Opening and closing of the morning flowers of the Tertoh avocado*

Dates of observations	Number of clusters	Time of opening and closing and number of flowers													Total
		7:00	7:30	8:00	8:30	9:00	9:30	10:00	10:30	11:00	11:30	12:00	12:30	1:00	1:30	
March 13, 1931	6	0	148	9	4	1	0	9d	1	0	0	— 3	108	39	4	163
March 14, 1931	6	9	129	33	5	2	0	0	1(6d)	(21d)	0	— 24	102	16	10	179
March 15, 1931	6	30	71	31	7	2	0	0	0	(5d)	(2d)	—29	88	16	1	141
Total	19	39	348	73	16	5	0	9d	2(6d)	(26d)	(2d)	—56	298	71	15	483

d=dropped.

TABLE 4.—*Opening and closing of the afternoon flowers of Tertoh avocado*

Dates of observations	Number of clusters	Time of opening and closing and number of flowers										Total
		2:30	3:00	3:30	4:00	4:30	5:00	5:30	6:00	6:30	7:00	7:30	
March 13, 1931	6		5	144	19	4	1	2	– 1	131	43		175
March 14, 1931	6		80	88	24	2	2	0	–50	105	39	2	196
March 15, 1931	6		82	52	10	6	1	0	–28	101	22		151
Total	18		167	284	53	12	4	2	–79	337	104	2	522

TABLE 5.—*Opening and closing of the morning flowers of the Pollock variety*

Dates of observations	Number of clusters	Time of opening and closing and number of flowers											
		6:00	6:30	7:00	7:30	8:00	8:30	9:00	9:30	10:00	10:30	11:00	11:30	12:00
March 16, 1931	6		113	52	37	12	0	3	2(2d)	0	0	1	0	0
March 17, 1931	6	35	78	72	43	18	4	2	0	0	0	0	0	0
March 18, 1931	6		16	84	79	40	13	6	0	0	0	1	0	0
Total	18	35	207	208	159	70	17	11	2(2d)	0	0	2	0	0

Dates of observations	Number of clusters	Time of opening and closing and number of flowers												Total
		12:30	1:00	1:30	2:00	2:30	3:00	3:30	4:00	4:30	5:00	5:30	6:00	6:30	
March 16, 1931	6	0	0	1	0	0	0	0	0	0	–23	43	145	8	221
March 17, 1931	6	0	–71	102	50	17	9	3							252
March 18, 1931	6	0	–13	46	109	52	18	1							239
Total	18	0	–84	1–148	159	69	27	4	0	0	–23	43	145	8	712

d = dropped.

TABLE 6.—*Opening and closing of the afternoon flowers of the Pollock variety*

Dates of observations	Number of clusters	Time of opening and closing and number of flowers														Total
		1:30	2:00	2:30	3:00	3:30	4:00	4:30	5:00	5:30	6:00	6:30	7:00	7:30	8:00	8:30	
March 16, 1931	6			37	129	46	13	2	0	−2	0	4	13	165	37	6	227
March 17, 1931	6	1	33	126	72	4	0	3	0	0	−58	156	24	1			239
March 18, 1931	6		17	179	94	19	5	0	0	0	−15	150	72	61	6		314
Total	18	1	50	342	295	69	18	5	0	2	−73	320	109	227	43	6	780

TABLE 7.—*Period of and time of maximum opening and closing of the morning and afternoon flowers of avocado*

	Morning flowers			Afternoon flowers		
	Number of flowers	Time of opening	Time of closing	Number of flowers	Time of opening	Time of closing
Pollock	712	6:00 a. m. to 11:00 a. m. Max. at 7:00 a. m.	1:30 p. m. to 6:00 p. m. Max. at 2:00 p. m.	780	1:30 p. m. to 4:30 p. m. Max. at 2:30 p. m.	5:30 p. m. to 8:30 p. m. Max. at 6:30; p. m.
Tertoh	483	7:00 a. m. to 10:00 a. m. Max. at 7:30 a. m.	12:00 noon to 1:30 p. m. Max. at 12:30 p. m.	522	3:00 p. m. to 5:30 p. m. Max. at 3:30 p. m.	6:00 p. m. to 7:30 p. m. Max. at 6:30 p. m.
Wester	524	8:30 a. m. to 11:00 a. m. Max. at 9:30 a. m.	11:00 a. m. to 2:30 p. m. Max. at 1:00 p. m.	425	11:00 a. m. to 3:00 p. m. Max. at 12:30 p. m.	5:30 p. m. to 7:30 p. m. Max. at 6:30 p. m.

TABLE 8.—*Results of observation on the time of dehiscence of pollen in avocado, Pollock variety*

Dates of observations	Time of bursting and number of anthers									Total
	8:00	8:30	9:00	9:30	10:00	10:30	11:00	11:30	12:00	
March 23, 1931			46	323	480	131	28	1		1,109
March 24, 1931			75	307	436	304	11	5	(2)	1,140
March 25, 1931	1	11	159	451	397	53	13	8	4(1)	1,098
Total number of anthers	1	11	280	1,081	1,313	488	52	14	4(3)	3,347

(2) = Number of anthers observed still closed and defective.

TABLE 9.—*Results of observation on the time of dehiscence of pollen in avocado, Wester variety*

Dates of observations	Time of bursting and number of anthers									Total
	1:00	1:30	2:00	2:30	3:00	3:30	4:00	4:30	5:00	
March 23, 1931		6	101	395	336	160	68	3	1	1,070
March 24, 1931		9	269	493	309	19	5	3	(1)	1,108
March 25, 1931		3	15	218	198	599	113	37	18(5)	1,206
Total number of anthers		18	385	1,106	843	778	186	43	19(6)	3,384

TABLE 10.—*Results of observation on the time of dehiscence of pollen in avocado, Commodore variety*

Dates of observations	Time of bursting and number of anthers									Total
	1:00	1:30	2:00	2:30	3:00	3:30	4:00	4:30	5:00	
March 27, 1931		34	317	234	490	17	7	2	(6)	1,107
March 28, 1931		149	289	251	38	13	8	1	1(6)	756
March 29, 1931		169	332	269	33	9	7	4	5(9)	837
Total number of anthers		352	938	754	561	39	22	7	6(21)	2,700

normally receptive at the time of dehiscence, pollination with another variety would be necessary for its normal fruit setting. In the establishment of avocado orchards the overlapping of the period of opening of the two groups of flowers in self-compatible varieties is of no little importance to consider. With self-incompatible varieties, however, this flower behavior is of course without any advantage, and cross-compatible varieties with opposite flower behavior should be interplanted.

Pollock.—At about 6 o'clock a. m., the morning flowers of the Pollock variety began to open, and continued until 11 o'clock a. m. However, on March 16th one of the 221 flowers opened at 1:30 o'clock p. m., an unusual variation which was probably due to the condition of the tree as affected by lack of soil-water. Likewise a considerable variation of results was obtained at the time of closing of the morning flowers. On March 16th the closing took place from 5 o'clock p. m. to 6:30 o'clock p. m., whereas on March 17th and 18th the flowers closed at 1 o'clock p. m. to 3:30 o'clock p. m. As stated, such variation may be attributed to lack of soil moisture, for on March 16th the soil was relatively dry; whereas, in the following two days the tree had received irrigation, so that the tree was then in the normal state, with respect to water supply.

With the afternoon flowers, opening was almost uniform but then the maximum opening on March 16th was delayed for about 30 minutes; whereas, the maximum closing was retarded about an hour. It seems obvious that under the condition of this experiment, lack of soil moisture tends to retard the opening and closing of the avocado flowers.

As in the variety Wester, there is in the Pollock variety a considerable overlapping between the periods of opening of the two groups of flowers so that pollination between flowers of the same tree is possible with consequent increase in fruit setting, unless the variety is inherently self-incompatible. It can be noted that this overlapping was more marked during the time when moisture was somewhat lacking in the soil. Such soil condition as water deficiency during pollination of avocado, might be of interest for physiological studies.

Based on the period between maximum opening and maximum closing of the same group of flowers from Table 7, it appears that in the Pollock the morning flowers remain opened for 7 hours, and its afternoon flowers for 4 hours. The morning flowers of the Tertoh variety opened for 5 hours and its after-

noon flowers for 3 hours. As to the Wester avocado, its morning flowers opened 3½ hours, and its afternoon flowers for 6 hours. All indications are that the avocado flowers had a shorter period during the first opening, while the stigmas are in a receptive state, than during its second opening when the pollen is being discharged.

In the Pollock variety the discharge of pollen takes place with the opening of the morning flowers, for it was noted that the flowers which open in the afternoon reopened to discharge pollen in the morning of the following day. On the basis of its flower behavior the Pollock variety may then be included in Group B, as Stout had classified it, and according to Ryerson's list of varieties under two general groups. The list which has been reproduced below from Ryerson(6), includes the different varieties observed by the writer at Lamao Experiment Station, thus marked (L) and those in the Tanauan Station, marked (T).

LIST OF AVOCADO VARIETIES CLASSIFIED ACCORDING TO THEIR FLOWER BEHAVIOR

Group A—with afternoon dehiscence	Group B—With morning dehiscence
1. Baldwin (L)	1. Cardinal (T)
2. Blakeman	2. Cyrus (L)
3. Challenge	3. Fuerte
4. Collison	4. Ganter
5. Colorado	5. Linda
6. Commodore (L)	6. Lyon (T)
7. Dickenson	7. Miami (L)
8. Grande	8. Panchoy
9. Manik	9. P. I. No. 4857 (L)
10. Mayopan	10. Pollock (T)
11. Murieta Green	11. Pollock (L)
12. Sharpless	12. Queen
13. Taft	13. Tertoh (L)
14. Taylor	14. Trapp
15. Vega (L)	15. Winslow
16. Wagner	16. Winsdowson
17. Walden	
18. Wester (L)	

2. TIME OF DEHISCENCE

Pollock.—The period of dehiscence in Pollock variety is from 8 o'clock a. m. to 12 o'clock noon with the maximum at 10 o'clock a. m. The maximum dehiscence on March 25th was at 9:30 o'clock a. m., or a half hour earlier than on the preceding days, where it started an hour earlier. This variation may

be partly explained by referring to Table 15, showing weather observations. On March 25th, the morning temperature of the air was relatively high, consequently the bursting of the anthers occurred earlier.

Wester.—In the afternoons of March 23, 24, and 25, 1931, the Wester variety dehisced its pollen from 1:30 o'clock p. m. to 5 o'clock p. m., with the maximum bursting of the anthers at 2:30 o'clock p. m.; an exception being observed on March 25th, when the air temperature was lower, and maximum discharge of pollen took place at 3:30 o'clock p. m., an hour later than those in the two preceding days. According to the results of observations on Pollock and Wester varieties, a difference of 1.4°C. or more in temperature of the air affects the time of greatest dehiscence.

Commodore.—With variety Commodore the period of dehiscence was normally similar to that of the variety Wester, that is, from 1:30 o'clock p. m. to 5 o'clock p. m., varying slightly in time of maximum bursting of the anthers, being 2 o'clock p. m., or a half hour earlier than that of the Wester variety. There is but little variation in the results of observations for the three consecutive days as may be expected from more or less uniform air temperature in the afternoons.

Cyrus.—The results of observations on the variety Cyrus runs parallel to those with the variety Pollock, i. e., the period of dehiscence being from 8 o'clock a. m. to 12 o'clock noon. The time of maximum dehiscence was at 9:30 o'clock a. m. as compared with 10:30 o'clock a. m. for Pollock. Again, here, the results are more or less uniform in three consecutive days.

Now with regards to the data for Pollock variety in Table 7 and those in Table 12, it appears that the maximum opening of the morning flowers was at 7 o'clock a. m. and its maximum dehiscence was at 10 o'clock a. m., or 3 hours after the maximum opening. In the Wester variety the maximum opening of the afternoon flowers occurred at 12:30 o'clock p. m., while the maximum dehiscence took place at 2:30 o'clock p. m., or 2 hours after the maximum opening. Notwithstanding the fact that these two series of data were taken in different periods yet it may be inferred that dehiscence usually takes place 2 or 3 hours after the opening of the flower. It was noted however that the Miami variety discharges its pollen shortly after the flowers open.

HYBRIDIZATION OF AVOCADO VARIETIES

The flower.—The avocado flowers are small, pale green to yellowish green in color and are born in more or less terminal

racemes which vary in form from open and spreading to closed and compact depending upon the varieties and species. Each flower is provided with 6 lanceolate or ovate petal-like structures or undifferentiated hypogynous perianth-lobes, one pistil, and from 9 to 12, generally 9 stamens. All flowers being perfect are inherently capable of developing fruits. The anthers are two-celled; these cells are opened at dehiscence by valves hinged upward. The pollen is very minute, almost invisible, measuring about .012 of a millimeter. Near the base of each stamen are two orange-colored glands secreting the nectar. There is one pistil, with a single ovule, slender style, usually hairy and a simple stigma.

Technique of hybridization.—In the hybridization of avocado there are some important features which must be taken into consideration for the success of the work. The avocado flower requires some special treatment which usually is not so important or may be overlooked when dealing with other kinds of flowers. For instance, in the selection and isolation of some flowers to be crossed there are certain stages of the flowers in which all the unnecessary parts and excess flowers should be removed lest the flowers left over to be crossed would develop abscission and soon fall down. The best time to remove all the excess parts of racemes is from 2 to 3 days before the flowers to be crossed open. Removing these excess parts 2 to 3 days after the flowers have been emasculated and cross-pollinated was found to be successful also. Removal a day before, a day after pollination, or on the day of crossing, resulted in failure, as the pollinated flowers fall in a day or two after trimming.

Moreover, it should always be remembered that, as a rule, the avocado has dichogamous flower with its stigma usually losing receptiveness before the anthers dehisce the pollen, that is, it is proterogynous. So in attempting cross-pollination with avocado it is well to emasculate and cross-pollinate the flower at its first opening. At this stage the stigma is not only receptive but also has a little chance of contamination by its own pollen, for the anthers are still securely closed. The flower is emasculated by clipping all the anthers by means of a fine pointed scissors or forceps, preferably the latter; considerable care being taken not to touch the stigma during the operation, for even the slightest contact with the instrument might snip the tender stigma.

Collection of pollen.—The pollen is obtained from the variety to be used as a male at least half an hour before the usual time

TABLE 11.—*Results of observation on the time of dehiscence of pollen in avocado, Cyrus variety*

Dates of observations	Time of bursting and number of anthers									Total
	8:00	8:30	9:00	9:30	10:00	10:30	11:00	11:30	12:00	
March 27, 1931		6	101	326	364	105	34	38	34	1,008
March 28, 1931		56	317	375	121	11	8	8	4	900
March 29, 1931	1	48	152	354	185	60	19	21	6(9)	855
Total of anthers	1	110	570	1,055	670	176	61	67	44(9)	2,763

TABLE 12.—*Period of dehiscence and time of maximum dehiscence in Commodore, Cyrus, Pollock, and Wester avocado varieties*

Variety	Number of clusters	Number of flowers	Number of anthers	Period of dehiscence	Time of maximum dehiscence
Commodore	13	300	2,700	1:30 p. m. to 5:00 p. m.	2:00 p. m.
Cyrus	18	307	2,763	8:00 a. m. to 12:00 noon	9:30 a. m.
Pollock	13	371	3,347	8:00 a. m. to 12:00 noon	10:00 a. m.
Wester	14	376	3,384	1:30 p. m. to 5:00 p. m.	2:30 p. m.

TABLE 13.—*Results of 1931 hybridization of avocado varieties*

Kind of cross	Date of crossing	Number of clusters	Number of blossoms	Number of fruits	Setting	Remarks
					Per cent	
1. Baldwin X Cyrus	3-31-31	2	44	0	0.0	Failure.
2. Baldwin X Pollock	3 25-31	4	102	1	1.0	Compatible. (?)
3. Commodore X Cyrus	3-28-31	8	316	22	7.0	Compatible.
4. Cyrus X Commodore	3-28-31	2	64	0	0.0	Failure.
5. Cyrus X Wester	3-27-31	2	88	0	0.0	Failure.
6. Miami X Wester	3-31-31	2	16	1	6.2	Compatible.
7. P. I. No. 4857 X Cyrus	4- 9-31	1	12	0	0.0	Failure.
8. P. I. No. 4857 X Wester	3-24-31	6	161	0	0.0	Failure.
9. Pollock X Miami	no record	2	no record	4		Compatible.
10. Pollock X Wester	3-16-31	10	496	3	0.6	Compatible. (?)
11. Tertoh X Wester	3-20-31	2	13	2	15.4	Compatible.
12. Wester X Cyrus	3-26-31	2	50	5	10.0	Compatible.
13. Wester X Miami	3-27-31	1	44	5	11.4	Compatible.
14. Wester X Pollock	3-16-31	9	577	19	3.3	Compatible.
15. Wester X Tertoh	3-13-31	9	598	15	3.8	Compatible.

TABLE 14.—*Results of natural and self-pollination in avocado*

Varieties	Kind of pollination	Date of pollination	Number of clusters	Number of blossoms	Number of fruits	Setting	Remarks
						Per cent	
Commodore	Self-pollination	3-31-31	4	57	6	10.5	
Cyrus	do	3-30-31	4	101	1	1.0	
Miami	do	3-30-31	3	93	4	4.3	
Pollock	Natural-pollination		5	1,039	0	0.0	Failure.
Pollock	Self-pollination	3-19 31	5	595	0	0.0	Failure.
Wester	Natural-pollination		10	1,650	0	0.0	Failure.

of dehiscence. Soon after the anthers burst very few pollen grains, if any, remain in the pollen sack. So, in getting pollen, some flowers before dehiscence are cut off whole from the racemes and put into any convenient receptacle such as small paper bags or seed envelops, small cardboard boxes or the like, where they are kept ready for use.

TABLE 15.—*Air temperature and relative humidity during the period of the experiment*

Date	Air temperature		Relative humidity		Remarks
1931	*6 a. m.*	*2 p. m.*	*6 a. m.*	*2 p. m.*	
February 23	22.3	31.7	99	59	Bright and clear.
February 24	22.4	32.0	92	57	Bright and clear.
February 25	23.0	35.5	96	66	Cloudy a. m. bright p. m.
February 26	21.5	32.5	91	56	Bright and clear.
February 27	20.0	31.9	96	53	Bright and clear.
February 28	23.5	31.5	83	60	Bright and clear.
March 12	23.0	33.6	90	54	Bright and clear.
March 13	23.6	32.8	86	58	Bright and clear.
March 14	23.0	33.0	91	58	Bright and clear.
March 15	22.5	33.0	88	57	Bright and clear.
March 16	24.0	32.1	91	64	Bright and clear.
March 17	24.5	33.4	93	62	Cloudy a. m. bright p. m.
March 18	24.2	32.5	91	65	Bright and clear.
March 19	24.3	33.0	90	59	Cloudy a. m. bright p. m.
March 20	24.5	33.2	89	63	Bright and clear.
March 21	25.5	32.3	88	68	Bright and clear.
March 22	26.5	32.6	84	69	Bright and clear.
March 23	23.5	31.6	96	81	Bright and clear.
March 24	24.5	31.4	92	83	2.5 mm. rain last night.
March 25	25.5	30.0	93	83	Moderate cloudy and windy.
March 26	23.5	32.7	94	84	Moderate cloudy and windy.
March 27	27.0	32.6	91	79	Bright a. m. cloudy p. m.
March 28	26.7	32.0	83	82	Bright a. m. cloudy p. m.
March 29	26.7	33.0	83	78	Bright and clear.

Pollination.—As soon as the flower has been emasculated the pollen is applied to the stigma. As the pollen grains are very minute and hardly visible with the naked eyes, the method used was to dislodge them on the finger tip painted with either black India ink or red ink which renders the pollen more visible. Thence, they are carefully transferred onto the stigma.

On the basis of flower behavior of different varieties dividing avocados into Group A and Group B, any cross falls under one of the following four systems of hybridization, where MD stands for the varieties that discharge pollen in the morning and AD for varieties dislodging pollen in the afternoon.

System No. 1 ..... AD×MD
System No. 2 ..... MD×AD
System No. 3 ..... MD×MD
System No. 4 ..... AD×AD

It is conceivable that in systems Nos. 1 and 2, the processes involved in crossing varieties with opposite flower behavior are somewhat different from those involved in crossing varieties belonging to the same group. In the first two systems as the stigma of one parent becomes receptive, the pollen of the other group simultaneously becomes available. On the other hand, with system No. 3, the pollen is collected in the morning and cross-pollination effected in the afternoon; whereas in system No. 4, the collection of pollen is done in the afternoon. Unless there should be considerable overlapping of periods of opening of the receptive morning flowers of the female variety and that of the dehiscent afternoon flowers of the male variety to effect cross-pollination in the same afternoon, the hybridization should be done in the morning of the following day. Thus, it becomes necessary to store the collected pollen overnight.

3. RESULTS OF HYBRIDAZATION

The crosses made in Lamao Experiment Station are shown in Table 13. It can be seen in this table that both the direct and reciprocal crosses of Miami x Wester; Tertoh x Wester; and Pollock x Wester, have produced some hybrid fruits, showing therefore that there are some degree of compatibility between these varieties. On the other hand, the direct crosses of Commodore x Cyrus and Wester x Cyrus have produced fruits whereas the reciprocals have failed. In the crosses of Baldwin x Cyrus, and P. I. No. 4857 x Cyrus and P. I. No. 4857 x Wester, no fruit set but a certain degree of compatibility is indicated in the crosses of Baldwin x Pollock and Pollock x Miami.

From the results obtained from our hybridization experiments, it appears that there are varieties of avocado that easily cross; hence, they are cross-compatible varieties. Some varieties are compatible only in one direction of crossing; hence partially compatible; and others may be entirely noncongenial or intersterile.

It was observed that after the emasculation and crossing of the afternoon blossoms of Pollock with Wester pollen, the flowers remained closed in the following morning, although ordinarily they should reopen at that time to dehisce their pollen. In the case of Commodore by Cyrus the cross-pollinated flowers had remained open much longer than the unpollinated. Cyrus blossoms crossed in the afternoon with Wester pollen reopened in the afternoon of the following day instead of in

the morning, as normally happens. The flower movement of the Wester variety was not affected at all when crossed with Pollock pollen.

It is evident that emasculation and cross-pollination exert some influence upon the movements of the flowers of certain varieties while in some others the treatment has no noticeable effects.

4. HAND-POLLINATION AND CROSS-POLLINATION

The results in Table 14, of selfing flowers of Commodore, Cyrus, and Miami at the time of dehiscence showed some setting of fruits suggesting not only that these varieties are self-fruitful but also some stigmas remain receptive till the second opening. In the case of Cyrus the percentage of setting was too low inviting some doubt as to the validity of the result. Both the natural and self-pollination with Pollock variety have had complete failure in spite of the fact that it showed a certain degree of cross-fertility when crossed with varieties Miami and Wester. Out of 1,650 flowers of the Wester under natural pollination no fruit set, but when sired with Cyrus, Miami, Pollock, and Tertoh it produced some hybrid fruits. It was observed through ocular examination that the stigmas of the varieties Pollock and Wester have turned brownish at the time of dehiscence which probably indicate loss of receptiveness. With the results obtained from Pollock and Wester it may be inferred that neither of these varieties is self-fertile and both may require cross-pollination with compatible varieties for a good setting of fruits.

Selection of seedling varieties.—The above results have practical bearing in the selection of isolated avocado trees grown from seedlings. Some seedling trees in isolation have not produced a single fruit although they have had several flowering seasons, each time producing flowers in abundance while some are very shy bearers and others have fruited well since their first flowering. The first type or nonproductive trees are so because they are incapable of self-fertilization, for some reason or other; this type requires good pollinizers for a normal fruiting. The second type or shy bearers are only capable of partial self-fertilization and like the first type they require good pollinizers for a larger production. The last type, the productive trees, capable of self-fertilization, and therefore self-fruitful, are the best materials for propagation and commercial planting, provided their fruits are commercially of good types and qualities.

Commonly, avocados are cross-pollinated plants on account of their flower behavior, so that a variety may be self-sterile yet may appear productive due t oother varieties growing near by, acting as good pollinizers. The influence of such pollinizing varieties needs careful consideration in selecting commercial types of avocados. It is therefore evident that the avocado growers are confronted with a greater and more intricate problem of pollination than that of the citrus or other tropical fruit trees, these plants being ordinarily self-fruitful.

The foregoing discussion has brought to light, with emphasis, some important considerations particularly in the selection of varieties for the commercial growing of avocado. If possible, only self-fertile, prolific, and regular bearing individuals should be planted in the orchard. Needless to say in this connection that the fruit of the chosen varieties should be of good size and shape, with good flavor and with the relatively small seeds and tight in the cavity. For a wide range of fruiting season, different varieties maturing in different months should be planted. In the case of cross-fruitful varieties only those that are cross-compatible should be set out systematically in the plantation. The pollinizers may be planted either in every third row or the third plant in the row. Pollinizing varieties so interplanted must have opposite flower behavior, so that as the one produces receptive stigma the other, its pollinizer, is at dehiscence and vice-versa.

SUMMARY

The movements, opening and closing of flowers both in the morning and in the afternoon, in the Pollock, Tertoh, and Wester varieties of avocado have been studied.

In the Wester variety the first opening of the flower took place in the morning, whereas in the Pollock and Tertoh the first opening occurred in the afternoon. The flowers which first opened in the morning ordinarily reopened in the afternoon of the following day to discharged pollen. And those which first opened in the afternoon reopened to discharge pollen in the morning of the following day. These flower movements are varietal characteristics so that avocado varieties may be classified into two groups; namely, Group A, with afternoon dehiscence and Group B with morning dehiscence. Dehiscence takes place in the second opening of the flower.

The period of dehiscence was studied in Commodore, Cyrus, Pollock, and Wester varieties. In the Cyrus and Pollock varie-

ties the period of dehiscence was from 8 o'clock a. m. to 12 o'clock noon with maximum at 9:30 o'clock a. m. and 10 o'clock a. m., respectively, and in the Commodore and Wester the period of dehiscence was 1:30 o'clock p. m. to 5 o'clock p. m., maximum at 2 o'clock p. m. and 2:30 p. m., respectively.

Observation of dehiscence in Pollock and Wester varieties showed that a difference of about 1.4 or more degrees centigrades in the temperature of the air would affect the time of maximum dehiscence.

It was found in the Pollock that dehiscence takes place about 3 hours after the opening of the flowers, and in the Wester 2 hours, although in the Miami the pollen was discharged very shortly after the flowers had opened.

According to Stout's system of classifying avocado varieties, the Baldwin, Commodore, Vega, and Wester varieties may be classified under Group A while the Cardinal, Cyrus, Miami, P.I. No. 4857, Pollock, Lyon, and Tertoh under Group B.

The best time to remove all the excess parts of the racemes is from 2 to 3 days before the flowers are to be crossed open, although 2 or 3 days after crossing was found effective with less success. The removal of the excess parts one day before or after the operation or at the time of pollination resulted in failure, as the cross-pollinated flowers fall off a day or two afterwards.

The proper time for emasculation and pollination is during the first opening of the flower. The movements of the flowers of some varieties had been influenced by emasculation and cross-pollination while in the Wester variety there was no evident effect.

From the result of hybridization experiments it was found that there are varieties that are cross-sterile; some varieties are compatible only in one direction of crossing; whereas, in others crossing has been successful either way.

The results of self-pollination in Commodore and Miami show that these varieties are self-fruitful.

Observation shows that some seedling avocado trees growing in isolated places are fruitless, others are shy bearers and some are good producers. It is concluded that the trees which are fruitless, though flowering regularly, are incapable of self-fertilization. The shy bearers are partially self-fertile. The first group needs pollinizers for larger production. The productive seedling trees in isolation are self-fertile; hence, they are the

best materials for commercial propagation and large scale planting.

The suggestion is made to the effect that in the selection of seedling varieties or in any comparative yield tests of different standard varieties of avocado, the pollination as a factor of production should always be taken into consideration; for self-sterile variety may appear very productive owing to some other variety or varieties growing nearby, flowering at the same time and acting as a good pollinizer, without which, the same self-sterile variety would be unproductive.

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FLAX IN THE PHILIPPINES

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FOUR PLATES

Of the many economic plants introduced into the Philippines, the flax is one that has never been given sufficient attention although it is well known that the cultivation of this plant, so useful to mankind, is as ancient as civilization itself. In Europe its cultivation is more ancient than that of cotton. It had been under cultivation for at least two thousand years before the Christian era in Mesopotamia, Assyria, and Egypt (1). In fact it is one of the oldest plants which has provided man his clothing.

The fiber is used for the manufacture of high grade cloths for garments, napkins, table runners and covers, towels, handkerchiefs, and strong sail-cloths. It is also made into twine for the manufacture of rope and cordage and strong sewing threads for shoe manufacture and fine embroideries. During the World War strong grade linencloth was made into wings for airplanes. From linen is obtained a pulp which is made into paper of varying qualities, from thick ones to a very thin kind, used for wrapping costly cigarettes.

The seed of this plant produces valuable oil, the linseed oil, used in making linoleum and oil cloth, for medicinal purposes, and as ingredient of paint and varnishes.

The common flax, *Linum usitatissinum,* belongs to the natural order of plants Linaceae or Flax family in which are included some of the less important perennial forms.

The following discussion is devoted to the statistics pertaining to flax and to the methods of culture; it also presents the results of some preliminary tests including the methods involved in the manufacture of crude fiber. It is hoped that this crop would find a place in the program of crop diversification and so increases the list of the possible home industries for the Islands.

VARIETIES OR TYPES OF ANNUAL FLAX

The common flax is divided into two distinct forms: seed-flax which is grown for seed, and fiber-flax which is grown for fiber.

The seeds from the latter group, although produced in much less quantity per plant, may also be used for the manufacture of linseed oil.

The varieties grown for fiber are taller, more slender, having less number of branches and amount of seeds than those grown for seeds, but producing superior fiber. In the United States, Canada, and Argentina, almost 99 per cent of flax are grown for seed production, whereas in Europe, most of the flax are raised for fiber manufacture. The principal growing countries are Russia, Poland, and France(2).

PRELIMINARY TEST WITH FLAX

In 1926, two varieties of fiber flax were received in the Bureau of Plant Industry: the Ireland Pureline No. 3 and the Saginao from the U. S. Department of Agriculture, Washington, D. C. The test which was made in Guinobatan, Albay, in May, 1926, was a failure. The same varieties were tested in the following November in Lamao Horticultural Station and in Baguio, Mountain Province. They showed very poor germination and the trials were discontinued.

Introduction in 1933 consisted of eight different varieties from the State College of Agriculture, Pullman, Washington. These are seed flax, North Dakota Nos. 114, 179, 187, and 188, Buda, Linota, Red Wing, and Winnona. All these were planted in November, 1933, and only North Dakota No. 187 had a fair stand and produced some seeds. The seeds were planted in May, 1934, and had good germination, but the standing water produced by the torrential rain had submerged the plot and destroyed all the seedlings completely.

Later, in 1934, two varieties of fiber flax, the Riga and the Dutch, were received from Sutton & Sons Seed Co., Reading, England. These varieties were tested in November, 1934, in the Central Experiment Station, Manila; in Baguio, Mountain Province; in the Economic Garden at Los Baños, Laguna; and in Lipa Experiment Station, Batangas.

Encouraging results of these culture were obtained for both varieties gave good crops in all the stations tried. The following table shows the average length of straw or height of plants, and average weight of fiber per thousand plants and the approximate yield per hectare based on plot yields:

TABLE I.—*Showing height and weight of straw and production of crude fiber based on 1,000 plants and estimated yield per hectare based on plot yields.*

Station	Variety	Straw		Crude fiber		
		Average height	Weight	Weight	Per cent	Estimated yield per hectare
		cm.	*gr.*	*gr.*		*Piculs*
Baguio Experiment Station	Riga	92.90	816.3	90.6	11.10	8.70
Central Experiment Station	Riga	81.85	737.5	78.5	10.60	7.30
Economic Garden	Riga	78.62	728.4	72.0	9.90	6.90
Lipa Experiment Station	Riga	72.20	708.0	68.5	9.70	6.20
Average		81.39	745.8	77.4	10.30	7.27
Baguio Experiment Station	Dutch	86.74	728.2	76.8	10.50	7.20
Central Experiment Station	Dutch	75.75	720.3	74.5	10.30	6.40
Economic Garden	Dutch	73.22	701.9	63.4	9.03	6.01
Lipa Experiment Station	Dutch	68.40	692.4	62.7	9.00	5.90
Average		76.03	710.6	69.3	9.71	6.38

NOTE.—One picul equals 63 kilos of crude fiber.

It appears from the results that the average height of the plants is 81.39 centimeters for the Riga and 76.03 centimeters for the Dutch variety and the average yields of crude fiber is 7.27 piculs for the Riga and 6.38 piculs for the Dutch. It is to be noted that the results from trials in Lipa Experiment Station are uniformly the poorest, for the plots were located in a place where it was dry and the soil is rather poor.

In this connection, it was observed that the November plantings are better than those in May. The reason is obvious that too much rain is likely to destroy the plants completely, or allow only abnormal growth. Flax may tolerate some light rain but when the weather is too dry, it makes stunted growth and the yield is considerably reduced.

CLIMATIC RELATIONS

Flax grows successfully in a wide range of latitude, from the tenth to the sixty-fifth north latitude and in a similar range of southern latitude(3). The Philippines is located between the fifth and the twentieth north latitude indicating a high probability that the raising of this crop might be possible in the Islands.

As to the temperature, this plant, especially the fiber flax, requires a moderately cool and damp weather, i.e. the plants

need a humid atmosphere and a relatively low and uniform temperature during the growing season(4). Such condition may be found in many places in the Philippines during November, December, and January. Too much rainfall is not favorable to the normal development of the plants while the hot and dry weather would check the growth, and stunt the plants, thus producing small quantity and poor quality of fiber.

SOILS AND FERTILIZERS

The kind of soil is not quite so important as the flax may grow well in soils ranging from loam to clayey soils which are practically the types of soils which maintain Philippine agriculture. It needs, however, a rather compact or a heavier subsoil with great capacity to retain moisture. According to Robinson and Cook(5), the heavier types of soil outyielded the lighter soils consistently.

Flax is not very hard upon soils for it takes no more plant food from a soil than many of the farm crops(5). As a crop, it is a rather shallow feeder. Fertilizer application would not be necessary provided that a proper crop rotation is maintained. Of all elements tested with fiber flax, only potash in combination with phosphorous seems to increase yield of fiber. The Philippine soils are heavily charged with these two elements so that, for the present, the application of fertilizer to this crop is not essential.

CULTURAL METHODS

The land intended for flax should be thoroughly prepared. The soil should be well pulverized and evenly surfaced, free from stubbles, rubbishes and clods. The subsoil should be made firm and compact. This may be attained by passing a heavy roller over the seed-beds before leveling the surface. Even or smooth surface of the sed-bed is necessary so as to have a uniform growth of the plants.

PLANTING AND SEEDING

In the Philippines, the flax should be planted at the end of the rainy season or during the cool months of the year when there are only some light rain or shower. In many places in the Philippines, November or early in December is the most appropriate time to plant flax. Moderately cool and damp weather is essential for the slow growth and elongation of the stem of fiber flax.

There are many ways of planting flax seeds. In Europe and in the United States, ordinary grain drills are employed in planting large areas but in small areas planting by hand is used, broadcasting the seeds and then harrowing them into the soil. In the Philippines, the latter method should be applied.

The seeds should be evenly distributed and should be buried from one half to an inch into the soil. Ununiform depth of planting will affect the growth of the plants, consequently poor quality of the fiber would result.

The flax seeds should be planted thickly to produce tall, fine and slender straw which yields long, fine, silky and soft fiber. Thick planting prevents profuse branching which will lower both the quantity and quality of the fiber. For fiber production, it will require from 70 to 100 kilos of seeds to plant a hectare. The quantity of the seeds depends upon the quality and percentage of germination of the seeds. For seed production, it will require much less amount of seeds, from 30 to 40 kilos per hectare.

In either case seeds for planting should be carefully graded and selected. Only sound, plumb seeds should be planted.

HARVESTING

The crop can be harvested for fiber in 75 days to 85 days and for seeds in 100 days or more, depending upon the prevailing weather. In warmer days, it takes shorter period.

There are three stages at which flax can be harvested: (*a*) the green ripe; (*b*) the yellow ripe; and (*c*) the full ripe. In the first stage, the plants have attained full bloom, but the stems and leaves are yet green. A very fine fiber, at this stage, can be extracted with great care. The second stage is when the lower one-third of the stem is yellowish, the leaves begin to drop off, and some 30 to 50 per cent of the seed bolls are ripe, yellow to brown in color, yielding about 70 per cent well developed brownish seeds; good for propagation, and oil production. At this stage, the fiber produced is silky and medium fine but much stronger than those from the first stage. Most flax for fiber is harvested at this stage. The third or last stage refers to the condition of the plant when all the leaves have dropped off and all the seed bolls are mature and the plants themselves are either matured or dead. At this stage the stem becomes too woody or hard and the fiber is lignified, losing its silkiness, luster, elasticity and strength. The seeds, however, are numerous. Seed flax is harvested at this stage.

Pulling by hand is the most common method used in harvesting fiber flax. There are three good reasons in favor of this method as against the method of cutting the stem, and these are: (*a*) it avoids staining and damaging of the fiber due to the entrance of moisture through the cut when the bundles of stems are set in small shocks to cure; (*b*) it gives better curing of straw and ripening of seeds; and (*c*) it produces straw of full length which means longer fiber(3).

THRASHING AND CARE OF SEEDS

After curing the straw, the calyx and the seed bolls become brittle; hence, the seeds are easily extracted without injury to both the stem and branches. The seed bolls are crushed into pieces and then by winnowing the seeds may be separated from the chaffs which are blown away with the lighter and poorly developed and immature seeds. All the plumb, sound and normal seeds, Plate 1, Fig. 1, should be kept dry in cloth or paper bags, placed in wooden box and then store the boxes in cool, dry and dark place, if possible in seed cabinet or larger boxes.

The flax seeds, like most oily seeds, soon lose their vitality when subjected to the warm and moist atmosphere. To prevent loss of germination, they should be kept dry and stored in dry cool place as stated above.

RETTING

After the stalks have been uniformly dried and cured, they are then retted for fiber extraction. Retting is the process by which the fiber is loosened from the woody portion of the stalks. During the process the gummy substances and the weaker tissues which tend to bind the fiber tissue together are dissolved.

There are three known methods of retting flax straw; namely, the chemical method, the water retting, and the dew retting. Up to the present, there is no successful retting by means of chemicals; they are either destructive to the flax fiber or they prove to be very expensive. Water retting has been used to a certain extent in some places in Belgium, Russia, and United States. The flax straw in bundles to be retted are placed in water in either tanks, reservoirs or in flowing rivers or streams. This method is rather delicate, needing a very close supervision by experienced hands.

The dew retting is more extensively used by the fiber-flax growing countries than either the water or the chemical methods.

This process is the most practical method used in the Philippines. The thrashed straw is evenly spread in thin layer in straight rows on a moist grassy meadow, Plate 4, Figures 1 and 2. The bacterial action facilitated by the presence of moisture from the dew and rain tend to dissolve the gummy substances and the weaker tissues which bind together the fiber tissue keeping it to cling to the woody portion of the stalk.

The flax straw is completely retted in 15 to 20 days during the drier months and in 10 to 15 days during the rainy season. During the process the straw is turned over once. For dew retting evenly growing grasses should be preferred to insure uniform retting. As soon as the cuticle can be easily separated mechanically and the separation of the fiber bundles from the rest of the cortex is rather easy, then the retting may be considered complete.

BREAKING, SCUTCHING, AND HACKLING

Thoroughly dried well retted straw looks bright with a peculiar sweet odor. The wood and the outer skin become harsh and brittle while the fiber is elastic and tough. The straw in small convenient size bundles, Plate 4, Figures 1 and 2, is pounded with wooden mallets, breaking the wood to short small pieces called shives. Then the shives are all removed by scutching. The scutched fiber is still reduced to finer divisions by a process known as hackling, Plate 3, Figures 1 and 2. Breaking, scutching, and hackling is done by machinery in the United States and other countries, although it is admitted that the best work is done by hand. By means of a well graded hackling, the fiber is divided finer and finer until the desired fineness for the spinner is produced.

CROP ROTATION

There is no better crop than the flax for crop rotation. Flax rotation would improve the soil chemically and physically, and controls weeds as well as diseases pernicious to it. In different countries, they adapt different lengths of rotation from five to ten intervening years between two crops of flax. They are, however, very particular about the crops that should precede the flax. They choose the leafy ones that will virtually control any weeds so that practically no weeds will come out to compete with the flax. In the United States, a crop of clover or a cleanly cultivated corn crop usually precedes the crop of flax. In Russia, flax is planted either on long-rested or fallowed land

TABLE 2.—*The quantity and value of linen and linseed oil importation in the Philippines, 1930–34.*[1]

Articles	1930		1931		1932		1933		1934		Average value for five years
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	
Linen cloths [a]	632,821	₱764,406	427,790	₱458,923	618,244	₱461,259	682,801	₱473,985	832,431	₱634,199	₱558,554.40
Table linen		71,248		52,354		61,572		30,151		17,109	46,486.00
Linseed oil [b]	735,164	341,625	599,691	179,236	766,494	150,120	607,688	123,354	591,548	152,838	189,434.60
Total value		1,177,279		690,513		672,951		627,490		804,146	794,475.00

[a] Meters. [b] Kilos. [1] Taken from the reports of the Philippine Islands Bureau of Customs.

TABLE 3.—*Flax (fiber). Area, production, and yield per hectare by continents*[1]

Countries	Area in hectares				
	Average 1924–28	1929	1930	1931	1932
Europe, including Russia	450,000	473,000	434,000	334,000	261,000
U. S. S. R. Territories of Europe and Asia	1,244,025	1,630,000	1,750,000	2,390,000	2,510,000
North America (Canada)	2,195	2,541	2,486	1,708	2,078
Asia, Japan and Chypre	14,000	11,000	9,000	11,000	10,000
Africa, Kenia and Egypt	1,000	2,000	1,000	1,000	1,000
Total	1,711,220	2,118,541	2,196,486	2,737,708	2,784,078

Countries	Production of flax fiber in piculs [a]					Yield per hectare in piculs				
	Average 1924–28	1929	1930	1931	1932	Average 1924–28	1929	1930	1931	1932
Europe, including Russia	3,407,936	3,901,587	2,953,968	2,060,317	1,507,936	7.6	8.2	6.8	6.2	5.7
U. S. S. R. Territories of Europe and Asia	5,048,570	5,714,285	6,194 127	8,730,159	7,936,508	4.1	3.5	4.0	3.7	3.2
North America (Canada)	44,794	64,765	87,634	43,473	51,148	20.4	25.5	35.2	25.4	24.6
Asia, Japan and Chypre	63,492	50.794	44,444	49,206	31,800	4.6	4.6	4.9	4.4	3.2
Africa, Kenia and Egypt	14,127	22,222	14,127	9,524	11,111	14.1	11.1	14.1	9.5	11.1
Total	8,578,919	9,753,653	9,294,300	10,892,679	9,538,503	5.0	4.6	4.2	4.0	3.4

[a] The figures in most cases refer to scutched flax including the tow fiber in some cases.
[1] Taken from the International Yearbook of Agricultural Statistics, official sources.

under grazing communal herd. Seeds of flax are successfully produced in newly open lands not only on account of the good amount of available plant food there is, but also because such lands are still free from diseases and weeds. In the Philippines, as the flax is a new crop, it is rather too early to suggest any system of crop rotation, but if it is to be tried the flax should follow any clean cultivated crops that will leave the soil free from weeds. A heavy good crop of upland rice or a well clean cultivated corn crop or peanut or other legumes may precede the flax.

DISEASES OF FLAX

The most important diseases of flax known in many flax growing countries are the wilt and the rust. In the Philippines, none of these diseases has as yet been observed.

Wilt.—The wilt which is caused by a fungus known as *Fusarium lini,* very often does much damage. The fungus attacks the roots and underground stem causing sudden wilting of plants in some parts of the field and sometimes in the entire field. The

TABLE 4.—*The imports of flax unmanufactured fiber into the United States by countries, 1926–27 to 1932–33.*[1]

Countries	1926–27	1927 28	1928–29	1929 30	1930–31	1931–32	1932–33	General average for U. S. imports
	Tons	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	
Latvia	898	1,520	2,176	2,231	1,926	1,836	18	1,515
United Kingdom	1,231	1,800	1,758	1,768	383	487	415	1,120
Russia Soviet	642	149	294	1,127	155	62	2,047	639
Belgium	446	739	757	810	536	157	217	523
Netherlands	287	253	208	231	154	67	12	173
Other European Countries	790	726	283	691	275	1,077	184	575
Canada	45	126	72	97	137	233	194	129
Other Countries	366	124	102	54	32			97
Total	4,705	5,437	5,650	7,009	3,598	3,919	3,087	4,771

[1] Taken from the Yearbook, United States Department of Agriculture.

control measure suggested is long period of crop rotation. Recently, in the United States, strains of flax resistant to wilt had been produced by selection. Careful grading and selection of the seeds for planting will avoid the introduction of disease organism into the soil(7).

Rust.—The common rust of flax is caused by a fungus called *Melampsora lini.* This is sometimes mistaken for wilt, but the

presence of reddish yellow clusters of spores, forming as spots upon the green leaves and black spots upon nearly matured stems, distinguishes rust from the wilt. Besides long crop rotation, a good seed treatment with formalin solution of one pound to 40 gallons of water will control the rust(6).

STATISTICS PERTAINING TO FLAX

In Table 2, it is shown that the average value of linen cloths and linen fabrics imported for the last five years, 1930 to 1934, inclusive, into the Philippines, was ₱605,040.40 per year and the value of linseed oil during the same period was ₱189,434.60 per year or a total of ₱794,475. This sum excludes the value of imported linen fiber mixed with other vegetable fiber. Our imports of flax-fiber goods alone would indicate that, as a buyer, the Philippines contributes a good sum every year to the flax industry of other countries.

Naturally and for obvious reasons our interest should first fall upon the possibility of producing unmanufactured flax fiber and the possible market abroad. Table 3 shows that the yearly world production ranges from over 8 million to almost 11 million piculs of crude fiber and the Union of Socialist Soviet Republics is the leading country, producing in 1932 over 70 per cent of the world production. Using the data on estimated yield per hectare from the different stations in the Philippines as shown in Table I, it will be noted that our yields compare very favorably with the world average yield per hectare. In fact the yield per hectare here is much higher than those of Russia and Japan, and almost equals those of Europe and Africa but is lower than that of Canada. It seems, however, that the average yield per hectare for Canada is unscrupulously too high. The United States, during the last 7 years, 1925 to 1933 inclusive, (see Table 4), has an average importation of 4,771 tons of crude flax fiber per year. (In 1932–1933, she imported 3,087 tons valued at ₱818,800 or 66.3 per cent.) If the Philippines could keep the United States as her favorable market, the raising of flax for crude fiber in this country would be a possibility.

The following figures, Table V, represent conservative estimates of cost of production and cash return from one hectare of fiber flax. In this table, the average yield was based on yields from trials in four different stations whereas the prices considered for crude fiber and tow were the average of foreign prices:

TABLE 5.—*Cost of production and cash return from one hectare of flax fiber*

COST OF PRODUCTION	
Preparation of land (clearing, plowing, harrowing, rolling and leveling)	₱30.00
Seeds, 80 kilos at ₱0.25	20.00
Planting	4.00
Harvesting including stocking and curing	14.00
Retting (spreading and picking)	6.00
Breaking, scutching, hackling and bailing	40.00
Miscellaneous expenses in marketing	10.00
Total expenses	124.00
RETURN PER HECTARE	
Long fiber, 6.82 piculs at ₱34.02	232.00
Tow fiber, 2.27 piculs at ₱8.50	19.30
Gross return per hectare	251.30
Total expenses	124.00
Expected net income	₱127.30

SUMMARY

Fiber flax is a short season or hardly a three-month crop for it can be harvested in 75 to 85 days from date of sowing.

It needs moderately a cool and damp or humid atmosphere. Nevertheless too much rain is not favorable to the crop. It tolerates some light rain or shower but a dry weather causes stunted growth, resulting in very poor yield.

With flax a well planned crop rotation is imperative in order to control weeds and diseases. Based on experiences of other countries, 5 to 10 intervening years between two crops of flax has been suggested. It has been pointed out that the breeding for disease resistant strains is a great possibility.

The preliminary tests made in the Philippines show an average yield for two varieties tested, the Riga and the Dutch, of 6.82 piculs of scutched fiber and 2.27 piculs of tow or short fiber per hectare. This yield compares favorably with the average yields of other flax-growing countries.

According to a conservative estimate of the cost of production and the cash return from one hectare of fiber-flax, a net profit of about ₱127.30 per hectare may be expected, not including the possible labor income of not less than ₱104 to the hectare.

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ILLUSTRATIONS

PLATE 1

Seeds of two varieties of fiber flax, (*a*) the Dutch and (*b*) the Riga, produced in the Central Experiment Station, Bureau of Plant Industry, Manila.

PLATE 2

FIG. 1. Trial plot of the Riga variety of flax at the Central Experiment Station, Bureau of Plant Industry, Manila.

2. Trial plot of the Dutch variety of flax at the Central Experiment Station, Bureau of Plant Industry, Manila.

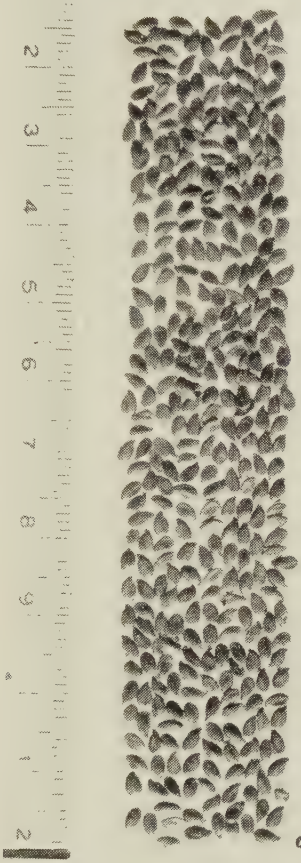
PLATE 3

FIG. 1. Straw of the Dutch and the Riga varieties showing their relative length.

2. Hackled or combed fiber of the two varieties, the Riga and the Dutch, prepared at the Central Experiment Station, Bureau of Plant Industry, Manila.

PLATE 4

Flax straw in the process of dew retting. Note the way the straw is spread on grasses and bundled after retting.



DUTCH FLAX SEEDS

RIGA FLAX SEEDS

PLATE 1.

1

2

PLATE 2.

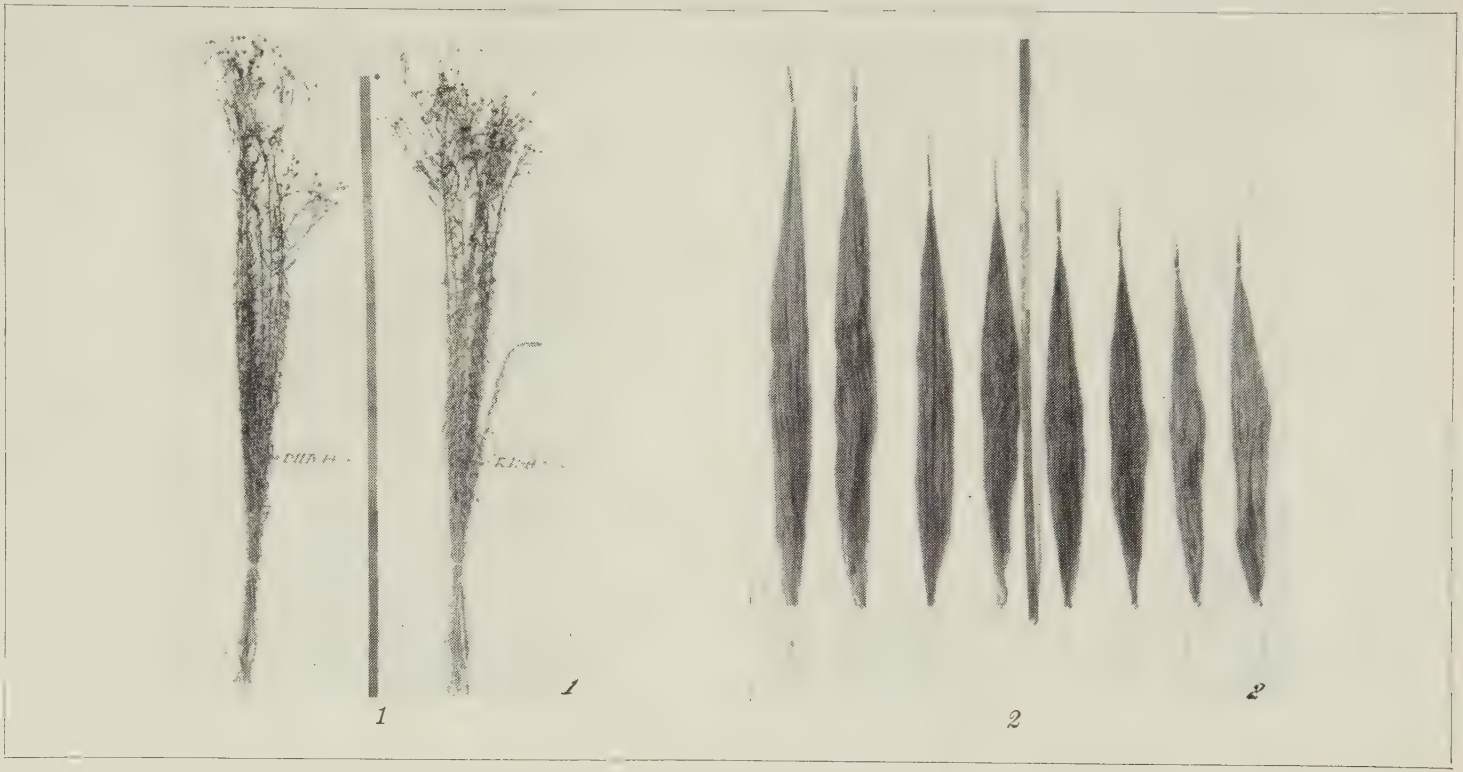


PLATE 3.

1

2

PLATE 4.

A PROGRESS REPORT ON THE INFLUENCE OF HEAT AND SMOKE ON THE DEVELOPMENT OF CARABAO MANGO BUDS (MANGIFERA INDICA L.)

By F. G. Galang and Julian A. Agati

Of the Horticulture Section, Bureau of Plant Industry

THREE TEXT FIGURES

The mango is generally known to be somewhat erratic in its flowering habits. If smudged, however, it may come into flower at almost any time of the year. In the Philippines, the normal flowering season of the mango is during the dry season—from January to April. Most of the flowers of the smudged trees that appear early in October and November or late in April may not set fruits at all because of showers or rains; whereas, a great percentage of those produced during the dry months—January, February, and March—may come to maturity. It is the desire of the growers to induce flowering as early as possible so that the fruits may command a better price in the market. Thus, in the Philippines, to attain this objective, the mango trees are smudged as early as October and as late as December or January. This practice is so popular in Bulacan, Bataan, Cavite, and Pampanga that it has almost become a part of the mango culture. While smudging is apparently effective, it is so laborious and expensive, especially in Cavite, Bulacan, and Pampanga where there is not much material available for the purpose. Hence, the method should be modified to make it more practical. Before discussing however the possibility of improving the present practice, it is necessary to study first the effect of the different components of the smoke which induce the mango either to flower or to produce new flushes. The object of the present investigation, therefore, is to determine the influence of heat, carbon monoxide, and carbon dioxide on the development of the mango buds.

REVIEW OF LITERATURE

So far as records show, Gonzales(7) and(8) Galang(5) were the first to investigate mango smudging. They reported that

bearing trees that are in a condition for forcing, that is, having mature twigs and leaves and with well formed dormant buds can be forced to flower any time of the year. Furthermore, Gonzalez(7) claims that heat, not the smoke, is the primary factor responsible for the development of the dormant stage of the buds into flowers. Galang(6) reported that by heating the ground under the tree by burning weeds and other combustible materials for eight times at intervals of a few days, a few twigs flowered. Higgins(10), in reviewing Gonzalez work, states, that the gases evolved by the smoke during smudging may be responsible also to a large extent for opening the mango buds. He calls attention to the papers of Denny(1) and (2) and Denny and Stanton(3) and (4) which demonstrated the effective use of gases or vapors of various volatile compounds for breaking the dormant stage of potato tubers and the dormant pot-grown woody plants. The woody plants were forced to bloom when exposed to certain chemical vapors; and that individual twigs and buds of the treated plant acted independently, that is, a single bud responded to this treatment if the selected twig or bud was allowed to come in contact with the vapor, while other twigs or buds protected from exposure to it did not flower. It is interesting to note also in this connection that Gonzalez(9) succeeded in hastening the ripening of chico fruits by the application of carbon dioxide gas. These artificial means of inducing fruits to ripen early are merely accelerating the natural processes which otherwise would proceed more slowly if no treatment is applied to the fruit. This in fact is analogous to any hastening in the maturing or opening of flower or leaf-buds of a given plant by artificial means.

MATERIALS AND METHOD

Originally there were 20 grafted Carabao mango plants used in this study. They were planted in large galvanized empty calcium arsenate drums, measuring from 42 to 49 cms. in diameter and from 30.5 to 38.5 cms. in depth, each having clay loam soil. The soil used is slightly deficient in phosphates as found out by the "plaque" [1] method test. The plants were grafted almost at the same time, and all have already flowered the previous year in petroleum cans. In order that the response or behavior of the plants may not be due to the in-

[1] Sackett, W. G. and Stewart Laura C., 1931. A bacteriological method for determining mineral soil deficiencies by the use of the soil plaque. Colorado Expt. Sta. Bul. No. 375. 1–36 pp.

sufficiency of the plant foods in the soil, the plants, on September 29, 1933, were fertilized with nitrophoska containing 15N–15P–18K at the rate of 400 kilos to the hectare (see Table I). The amount of fertilizer applied per pot was based on the volume of the soil it contained. The fertilizer was broadcast and the surface soil, including the non-fertilized pots, was cultivated afterwards. The pots were then covered with pieces of petroleum can to avoid leaching of the fertilizer in case of rain. The plants used were badly shaken by the October typhoons in 1934 and eaten up by the tip borers so that most of them had young flushes at the time of the experiments—January 7 to February 25, 1935.

The plants were divided into four groups, each group having five plants, except Group II. The fifth plant of this group—Tree No. 4—was badly attacked by scale insects.

The plants in Group I—Tree Nos. 6, 10, 11, 12 and 15—were used to find out the effect of pre-cooled smoke in forcing the mango buds. In order to keep as much of the smoke as possible around the plants within a considerable period, the plants were enclosed in a rectangular chamber, measuring $4 \times 3 \times 3$ meters, having celophane paper walls. One side of the chamber was provided with a small door. The smoke was supplied to the plants by means of a device consisting principally of an oven, smoke-stack, flue, cooling chambers, hose and nozzles (Fig. 1). The oven or stove placed horizontally on the ground is made from an old empty crude oil drum. It has doors on one side, having movable shutters that hinged at the middle. A perforated tray extending horizontally at the midle throughout the length of the oven, divided the latter into two compartments. The upper compartment is for fueling and the lower is for ventilation and for disposing the ashes. The other end of the oven is fitted with a smoke-stack and a short flue through which the smoke forces its way out into the chamber where the plants are kept. Before reaching the plants, the smoke passes through a series of four cylindrical drums, about 29 cms. in diameter and 34 cms. in length, connected with each other by arms of galvanized iron sheet, 7 cms. in diameter. The cylinders are held in place in a trough of galvanized iron sheet, 141.5 cms. long, 47 cms. wide and 43 cms. deep and filled with water. But owing to some leakage in two cylinders, which was discovered when the experiment was already under way, the trough is filled up with coconut coir-dust constantly wetted with water so as to cool the smoke passing through the

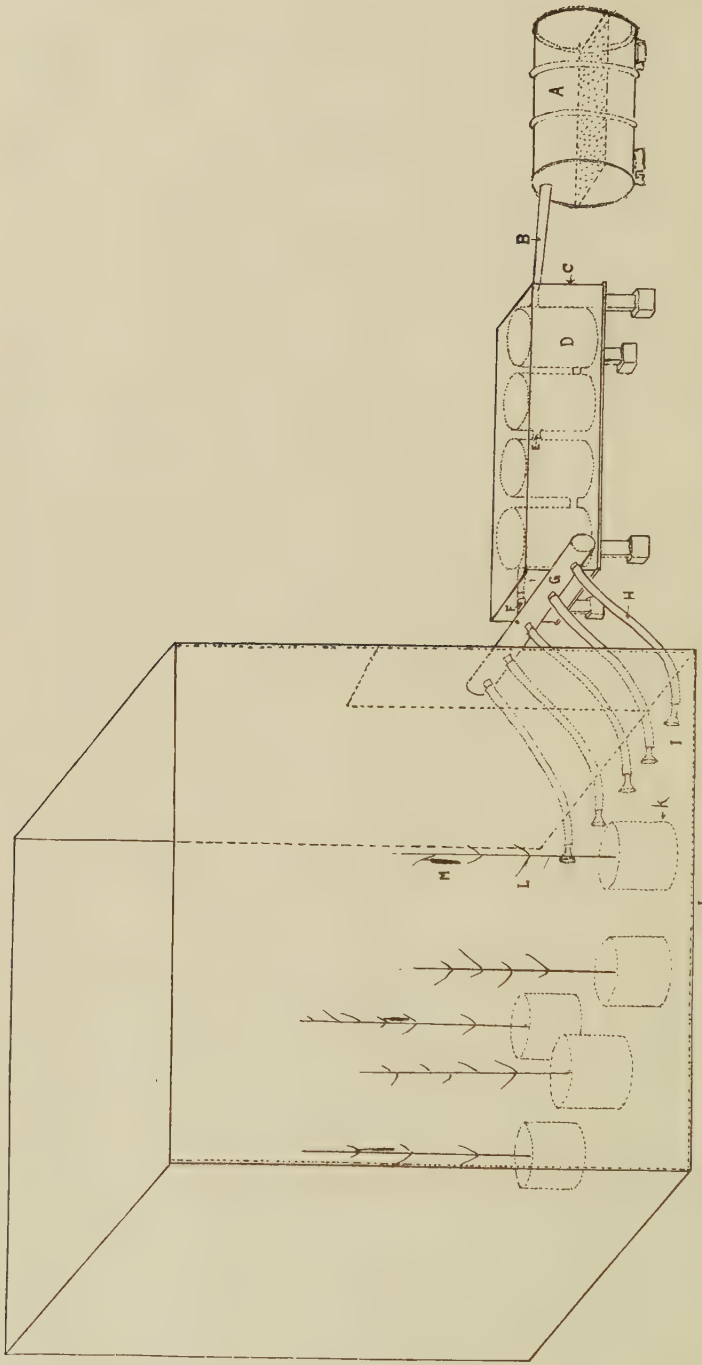


FIG. 1.— An assembly of the apparatus used for producing the precooled smoke before reaching the plants. (A.)—the oven; (B.)—smoke stack and flue; (C.)—trough for water; (D.)—cooling cylinders; (E.)—arms and passage; (F.)—arms and passage; (G.)—perforators; (H.)—hose; (I.) nozzle; (J.)—chamber; (K.)—galvanized pails containing the plants; (L.)—plants; (M.)—Thermometer.

cylinders. The trough is provided with an outlet in one corner at the bottom through which the water can leak constantly. This allows the constant soaking of the cooler with fresh water from a nearby faucet without overflowing the trough. The cylindrical tube is provided with five holes, which are equidistant to each other. Each hole has a short arm which exactly fits a corresponding hose that extends to the plants in the chamber. Each hose is connected to a perforated nozzle which allows a slow and uniform evolution of the smoke around the treated plants in the chamber.

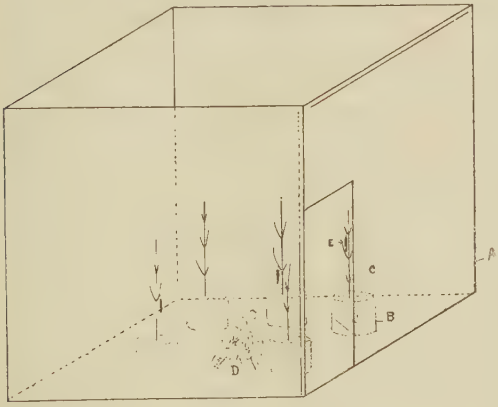


FIG. 2. Sketch of abacá-sack cloth chamber for ordinary smudging. A.—Chamber made up of abacá cloth; B.—Galvanized pails containing the plants: (C.)—plants; D.—Graphic representation of the fire; E.—Thermometer.

The plants in Group II—Tree Nos. 5, 8, 13, and 17—were placed in another chamber whose walls were made only of abacá cloth instead of cellophane paper (Fig. 2). The plants were arranged in a circle so as to permit the building of a fire on a stove at the middle made of iron drum of about one-half a meter high and 60.7 cms. in diameter.

The third group of plants—Tree Nos. 14, 16, 18, 19, and 20—was not exactly enclosed in a well built chamber like the other experiments (Fig. 3). Later on Plant No. 9 of the control was added to this group, when three of the plants wilted because of over-heating. However, just to keep the heat uniformly distributed among the plants, loosely joined abacá cloth was put around. The plants were also placed in a circle to allow a space for a stove at the middle. Wood charcoal was exclusively used for fuel in order to avoid smoke as much as possible. Later on a stove was placed for every two plants in order to provide more heat.

The last group of plants—Nos. 1, 2, 3, 7 and 9—which was used as control did not receive any treatment, nor were they inclosed in a chamber. However, the plants were placed side by side in a rectangular arrangement in a well exposed place a little distance from the other experiments.

Three thermometers were used for recording the temperatures in each treatment, and each of them was hung on the branches of the plants. The temperatures were read hourly during each run of the experiments.

Through the coöperation of the Chemistry Section, it was possible to undertake a daily analysis of the smoke in each set of experiments. The fuel used in the first two sets of experiments consisted of pieces of wood and bamboo, abacá waste, and dry leaves and grasses. Occasionally fresh grasses were used in order to produce a sufficient volume of smoke and to keep the fire as low as possible. For testing the effect of heat, as previously stated, wood charcoal was exclusively used to avoid any smoke as much as possible.

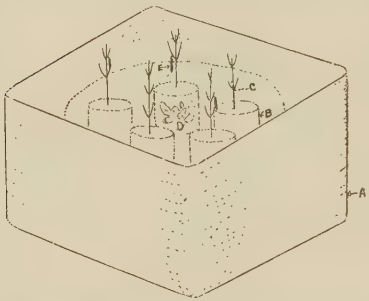


FIG. 3.—Loosely abacá-sack cloth chamber for the plants used in testing the effect of heat alone. A.—abacá cloth loosely arranged around the plants to keep the heat around the plants as long as possible. B.—Galvanized pail containing the plants; (C.)—plants; D.—Graphic representation of the fire; E.—Thermometer.

The plants were maintained more or less under the same moisture condition by withholding the watering of the soil during the course of the experiment. Unless the plants showed signs of insipient wilting, watering was avoided. This is to check the excessive vegetative growths which may result from too much moisture in the soil and which retard the flowering of the trees. By not watering the soil temperatures were kept more or less uniform throughout.

This preliminary test lasted for 49 days, or until the mature twigs have developed either leaf—or flower-buds, as follows: Pre-cooled smoke—January 7–February 16, 1935; heat and smoke—January 7–February 9, 1935; and heat alone—January 7–February 25, 1935.

The results of the experiments are presented in Tables II, III, IV, and V.

DISCUSSION OF RESULTS

Table II shows that the flushes of the treated plants varied in age from three to five months old. It may be seen also that the response of the buds to the treatment was evident after a month, and continued to prevail in about a week thereafter until 48 out of 70 buds have opened.

The data indicate quite clearly that the intensity of both the carbon dioxide and the carbon monoxide is greater in the morning than in the afternoon—2.4 against 1.4 per cent. Moreover, while carbon dioxide was high in the morning it dropped in the afternoon, from 1.8 to 0.87 per cent. The decline of the carbon monoxide in the afternoon was not to such a great extent as that of the carbon dioxide. On the whole, carbon monoxide was present in excess of the carbon dioxide, however.

The average daily temperature around the plants was 28.9°C. in the morning and 31.2° C. in the afternoon. The former had an increase of 1.5° C. over the ordinary air temperature for the same period, while the latter had an increase of 2.4° C. Judging from these slight increases of temperatures over the air temperature, it may be stated that the smoke had been kept reasonably cool during the experiment. It is also quite clear that the smoke as produced contained an appreciable quantity of carbon dioxide, and of this amount a great excess was already present in the air, while carbon monoxide produced exclusively by the smoke existed in great abundance.

Table III shows that the age of the twigs used varied from two to five months, and the opening of the buds commenced in 8 days. Most of them, however, opened after about a month, and most of the buds opened one after another in 3 days' time. One-hundred per cent of the buds produced new flushes.

The daily amounts of carbon dioxide and of carbon monoxide were strikingly higher than those shown in Table II both in the morning and afternoon—2.9–4.4 per cent monoxide and 2.4–3.8 per cent dioxide. Besides, the carbon dioxide in the afternoon exceeded that in the morning by 1.4 per cent, which was quite the reverse of the results appearing in Table II.

The morning temperatures around the plants were slightly less than those in the afternoon. In the morning the temperature around the treated plants was 2.2° C. over the air temperature, while in the afternoon there was a difference of 3.2° C. in favor of the former.

The plant having 5-month-old twigs had buds developed in 8 to 10 days as shown in Table IV. No response on trees having younger buds—2.5–4 months old—has been obtained, while the three remaining plants were discarded before the close of the experiment owing to wilting as a result of overheating and neglect of watering. The plant that responded was somewhat abnormal in its growth, however. As a matter of fact, the branch that gave rise to numerous leaf-buds at its

basal portion was previously injured by typhoon and mango borers.

The amounts of carbon dioxide and of monoxide were comparatively large—3.6–4.0 per cent dioxide and 4.3–4.6 per cent monoxide. In the morning the two gases occurred in more or less the same quantity, and in the afternoon the carbon dioxide was slightly less than the carbon monoxide. On the whole, both the monoxide and dioxide in the morning were greater than those in the afternoon by 0.3 and 0.04 per cent, respectively.

The prevailing temperatures around the plants morning and afternoon were 30.9°C. and 32.3°C., respectively, or an increase of 3.4°C. over the ordinary air temperature in each case. The morning and afternoon air temperatures were then 27.5° C. and 28.9°C., respectively.

The average intensity of carbon dioxide around the plants in the control ranged from 0.02 to 0.03 per cent only, and the temperature was 28.2°C.

According to the results of the experiment as shown on Tables II and III, it is evident that the developments of the buds on two-to five-month-old twigs of potted Carabao mango plants that have flowered previously were hastened by means of smudging. On the other hand, when heat alone was applied only one plant responded, which plant has been severely injured by typhoon and insects. Because of this condition the plant in question is likely to produce new shoots even without any treatment at all. As in the control all plants remained unchanged except in one case where new bud formation was to be expected because of the poor condition of the plant resulting from insect and typhoon injury.

The buds responded to ordinary smudging in a shorter time than when subjected to a smoke passed through a cooler. In the former case bud development was noticeable as early as eight days on 5-month-old twigs and 29 days on younger twigs, while on the latter (smoke alone) the earliest was 31 days on 4-month-old twigs and 33 to 38 days on 3½ to 5-month-old twigs.

The presence of a large quantity of smoke having from 2.9 to 4.4 per cent carbon monoxide and 2.4 to 3.8 per cent carbon dioxide, readily activated the buds. Under these conditions, or when the supply of carbon dioxide and monoxide was in the proportion of 3.1 to 3.65 per cent the resting period of the buds lasted only 8 to 29 days. With pre-cooled and very slow current

of smoke containing from 1.4 to 2.4 per cent carbon monoxide and 0.87 to 1.8 per cent carbon dioxide and where the rise of temperature was only from 1.5 to 2.4° C., the buds developed in 31 to 35 days. The volume of carbon dioxide was 1.33 per cent and the monoxide was 1.90 per cent. With less intensity of smoke, having from 4.3 to 4.6 per cent carbon monoxide and 3.6 to 4.0 per cent carbon dioxide, or an average of 4.45 and 3.8 per cent, respectively, but with higher temperature of 3.4° C., practically there was no change on the treated plants.

It is strikingly noteworthy that the effect of a medium temperature and a dense cloud of smoke exhibited a more forcing effect on the opening of the dormant mango buds. Moreover, under these conditions bud opening was somewhat simultaneous irrespective of their age. On the other hand, the stimulation resulted from smoke alone, and with lower temperature was not so readily manifested by the plants and the bud opening occurred at longer intervals. In both cases, however, the opening of the older buds was always earlier than the younger ones.

The response to medium and higher temperatures with dense or less intensity of smoke was almost in all cases vegetative growths; whereas in plants subjected at lower temperature with moderate and pre-cooled smoke, flower buds were formed. In this experiment flower buds were produced when the temperature was about 30.0° C., and the carbon dioxide were 1.33 and 1.9 per cent by volume, respectively.

CONCLUSIONS

The results showed that both the presence of gases and a certain degree of temperature are factors responsible for the stimulation of the growth or development of mango buds.

It is also apparent from the results of these experiments that where heat, carbon dioxide and carbon monoxide were present in more or less low degrees or quantities, flower as well as leaf-buds were produced. Whereas if these factors were excessive only leaf buds were formed.

Where no stimulating factors were applied as in the control, the buds remained undeveloped.

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TABLE I.—*Showing the conditions of the plants and the treatments given*

Pot number	Treatments							Condition of the plants
	Control	$CaCO_3$	Na_2HPO_4	K_2HPO_4	K_2SO_4	N (per cent)	15–15–18 Nitrophoska	
							(*gms.*)	
1	+	+	++++	0	+	0.09	35	Good—with 5 twigs and 53 leaves.
2	0	X	+++	0	X	0.02	37	Excellent- with 3 branches bearing 6 twigs and 146 leaves.
3	0	X	+++	0	X	0.19	36	Excellent—with 2 branches bearing 11 twigs and 111 leaves.
4	+	+	+++	0	X	0.21	38	Excellent- with 2 branches bearing 5 twigs and 90 leaves.
5	+	+	+++	0	+	0.17	----------	Excellent—with 2 branches bearing 8 twigs and 81 leaves.
6	X	X	+++	0	X	0.10	37	Fair—with 6 twigs and 81 leaves.
7	X	X	+++	0	X	0.17	34	Poor—with 4 twigs and 34 leaves.
8	+	+	++++	X	X	0.06	39	Good—with 4 twigs and 53 leaves.
9	X	X	+++	0	X	0.10	----------	Excellent— with 7 twigs and 64 leaves.
10	0	X	+++	0	X	0.09	34	Excellent- with 3 branches bearing 6 twigs and 48 leaves.
11	0	X	+++	0	X	0.14	----------	Excellent—with 8 twigs and 100 leaves.
12	+	+	+++	+	X	0.16	38	Good—with 5 twigs and 60 leaves.
13	X	X	+++	++	++	----------	38	Poor—with 4 twigs and 22 leaves.
14	+	+	+++	++	+	0.16	38	Excellent—with 3 branches bearing 9 twigs and 95 leaves.
15	X	X	+++	0	X	----------	35	Poor—with 2 poorly developed branches bearing 2 twigs and 25 leaves.
16	+	+	+++	0	+	0.08	33	Excellent—with 3 branches bearing 6 twigs and 85 leaves.
17	+	+	+++	++	+	----------	30	Fair—with 1 terminal growth and 26 leaves.
18	+	+	+++	+	X	0.18	34	Poor—with 2 twigs and 16 leaves.
19	+	X	++++	0	X	0.08	33	Good—with 2 branches bearing 6 twigs and 79 leaves.
20	0	0	+++	++	X	----------	----------	Excellent—with 2 branches bearing 10 twigs.

LEGEND:

0=No growth.
x=Soil eruption.
+=Very slight growth.
++=Slight growth.
+++=Moderate growth.
++++=Abundant growth.

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TABLE II.—*Showing the effect of smoke on the development of mango buds*

Tree number	Total number of twigs per tree	Approximate age of twigs (months)	Analysis of smoke: Pct. by volume of gases found per day (morning)		Analysis of smoke: Pct. by volume of gases found per day (afternoon)		Average daily temperature of trough		Average temperature around the plants in the chamber	
			Carbon dioxide	Carbon monoxide	Carbon dioxide	Carbon monoxide	A. M.	P. M.	A. M.	P. M.
							°C.	°C.	°C.	°C.
6	15	3-5	1.8	2.4	0.87	1.4	30.5	32.6	28.9	31.2
10	23	3½-5	1.8	2.4	0.87	1.4	30.5	32.6	28.9	31.2
11	11	4	1.8	2.4	0.87	1.4	30.5	32.6	28.9	31.2
12	8	5	1.8	2.4	0.87	1.4	30.5	32.6	28.9	31.2
15	13	4	1.8	2.4	0.87	1.4	30.5	32.6	28.9	31.2

Tree number	Total number of twigs per tree	Approximate age of twigs (months)	Average daily air temperature		Rise in temperature in the cellophane chamber		Weather: Number of clear days during the experiment	Weather: Number of cloudy days during the experiment	Number of days of which buds became active	Number of buds developed into—	
			A. M.	P. M.	A. M	P. M.				Flushes	Flowers
			°C.	°C.	°C.	°C.					
6	15	3 - 5	27.4	28.8	1.5	2.4	22	13	35–38	15	
10	23	3½-5	27.4	28.8	1.5	2.4	22	13	38	2	
11	11	4	27.4	28.8	1.5	2.4	22	13	31–38	9	2
12	8	5	27.4	28.8	1.5	2.4	22	13	35–38	8	
15	13	4	27.4	28.8	1.5	2.4	22	13	33–38	12	

TABLE III.—*Showing the effect of heat and smoke on the development of mango buds*

Tree number	Total number of twigs per tree	Approximate age of twigs (months)	Analysis of smoke				Average daily temperature around the plants in		Average daily air temperature		Rise in temperature around the plants in the chamber		Weather		Number of days of which buds became active	Number of buds developed into—	
			Pct. by volume of gases found per day (morning)		Pct. by volume of gases found per day (afternoon)								Total number of clear days during the experiment	Total number of cloudy days during the experiment		Flushes	Flowers
			Carbon dioxide	Carbon monoxide	Carbon dioxide	Carbon monoixde	A. M.	P. M	A. M.	P. M.	A. M.	P. M.					
							°C.	°C.	°C.	°C.	°C.	°C.					
5	9	3.5–5	2.4	2.9	3.8	4.4	29.5	31.7	27.3	28.5	2.2	3.2	18	11	29–31	9	
8	6	5	2.4	2.9	3.8	4.4	29.5	31.7	27.3	28.5	2.2	3.2	18	11	29–31	6	
13	3	2	2.4	2.9	3.8	4.4	29.5	31.7	27.3	28.5	2.2	3.2	18	11	29–31	3	
17	5	5	2.4	2.9	3.8	4.4	29.5	31.7	27.3	28.5	2.2	3.2	18	11	8–9	5	

TABLE IV.—*Showing the effect of heat alone on the development of mango buds*

Tree number	Total number of twigs per tree	Approximate age of twigs (months)	Analysis of smoke: Pct. by volume of gases found daily (morning)		Analysis of smoke: Pct. by volume of gases found daily (afternoon)		Average daily temperature around the plants		Average daily air temperature		Rise in temperature around the plants		Weather: Total number of clear days during the experiment	Weather: Total number of cloudy days during the experiment	Number of days of which buds became active	Number of buds developed into—	
			Carbon dioxide	Carbon monoxide	Carbon dioxide	Carbon monixde	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.				Flushes	Flowers
							°C.	°C.	°C.	°C.	°C.	°C					
9	8	4	4.0	4.6	3.6	4.3	30.9	32.3	27.5	28.9	3.4	3.4	25	14			
14	20	2½	4.0	4.6	3.6	4.3	30.9	32.3	27.5	28.9	3.4	3.4	25	14			
19	5	5	4.0	4.6	3.6	4.3	30.9	32.3	27.5	28.9	3.4	3.4	25	14	8–10	5	
16																	
18																	
20																	

NOTE.—Tree Nos. 16, 18, and 20 wilted due to over heating, while Tree No. 9 in the control lot was later on added in this experiment.

TABLE V.—*Showing the development of buds on the control plants*

Tree number	Number of twigs per tree	Approximate age of twigs (months)	Daily fluctuations of gases in the air Pct. by volume		Average daily air temperature		Weather		Number of days of which buds became active	Number of buds developed into—	
			Carbon dioxide	Carbon monoxide	A. M.	P. M.	Total number of clear days	Total number of cloudy days		Flushes	Flowers
					°C.	°C.					
1	19	5	0.02–0.03		27.5	28.9	25	14			
2	19	3½–5	0.02–0.03		27.5	28.9	25	14			
3	10	5	0.02–0.03		27.5	28.9	25	14			
7 [a]	7	5	0.02–0.03		27.5	28.9	25	14		7	
9 [b]	9	4	0.02–0.03		27.5	28.9	25	14			

[a] Tree No. 7 was badly affected by the typhoon on October 16 and 20, 1934. The crown was almost totally broken; hence, new shoots appeared.
[b] Tree No. 9 was transferred to group III (heat alone), on January 15; at this time there was no apparent signs of bud development.

ILLUSTRATIONS

TEXT FIGURES

FIG. 1. An assembly of the apparatus used for producing the precooled smoke before reaching the plants.
(A) The oven; (B) Smoke stack and flue; (C) Trough for water; (D) Cooling cylinders: (E) and (F) Arms and passage; (G) Perforators; (H) Hose; (I) Nozzle; (J) Chamber; (K) Galvanized pails containing the plants; (L) Plants; (M) Thermometer.

FIG. 2. Sketch of abacá-sack cloth chamber for ordinary smudging.
A—Chamber made up of abacá cloth
B—Galvanized pails containing the plants, (C)
D—Graphic representation of the fire
E—Thermometer

FIG. 3. Loosely abacá-sack cloth chamber for the plants used in testing the effect of heat alone.
A—Abacá cloth loosely arranged around the plants to keep the heat around the plants as long as possible.
B—Galvanized pail containing the plants, (C)
D—Graphic representation of the fire
E—Thermometer

THYSANOPTERA OF THE PHILIPPINE ISLANDS[1]

By Dudley Moulton

The present paper has been made possible through the cooperation of several entomologists who have collected thrips in the Philippine Islands and have forwarded them to me for study and identification. I appreciate especially the coöperation of Mr. Jose S. Camus, Director of Plant Industry, the Department of Agriculture and Commerce; and of Miss I. D. Dobrosky, D. T. Fullaway, and W. D. Pierce. Part I, devoted to *TEREBRANTIA,* includes records of fifteen species already known in other countries and the description of ten species new to science, whose habitat, at the present writing, is limited to the Philippine Islands. The types of these new species remain in the author's collection. Identified specimens of most of the species listed here, however, are being deposited with the Bureau of Plant Industry, Department of Agriculture and Commerce, Manila.

Part I, Terebrantia

Superfamily Thripoidea Hood, 1915

Family THRIPIDÆ Uzel, 1895

Subfamily HELIOTHRIPINAE Karny, 1921

SELENOTHRIPS RUBROCINCTUS Giard, 1901.

One specimen (female) taken on grass at Manila, July 7, 1931. (I. D. Dobrosky) (Moulton No. 4671).

BUSSOTHRIPS CLARATIBIA Moulton, 1935.[2]

Three collections made by Miss I. D. Dobrosky as follows: on leaves of pink flowering cotton, July 9, 1931, and on grass, July 22, 1931, at Los Baños; on a legume, October 20, 1931, in Laguna, P. I.

Subfamily PANCHAETOTHRIPINAE Bagnall, 1915

TRYPHACTOTHRIPS RUTHERFORDI Bagnall, 1915.

On cotton, *Gossypium brasiliense,* July 16, 1928, (No. 4255) and on *Canna speciosa* March 14, 1929, (No. 4271) at Victorias,

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[1] Received for publication January 16, 1936.

[2] See *Philippine Journal of Agriculture,* Vol. 6, No. 4 (1935).

Occidental Negros, (W. D. Pierce); on leaves of pink flowering cotton at Los Baños, July 9, 1931, and on a legume October 20, 1931, in Laguna, P. I. (I. D. Dobrosky). (No. 4666).

Subfamily CHIROTHRIPINAE Karny, 1921

CHIROTHRIPS MEXICANUS Crawford, 1909.

Two collections from grass taken on June 26 and July 7, 1931, at Manila. (I. D. Dobrosky) (Nos. 4671, 5077).

Subfamily SERICOTHRIPINAE Karny, 1921

Tribe SERICOTHRIPINI Priesner, 1926

SCIRTOTHRIPS DOBROSKYI, new species.

Female Holotype: Uniformly light orange yellow, head lighter, legs concolorous with body except tips of tibiae and all tarsi which are clear yellow; first segment of antenna clear, II to VIII uniformly brown; wings uniformly brown; crescents of ocelli deep orange red; prominent body and wing spines brown.

Total length, .66 mm.; antennal segments length (width), III, 30(15); IV, 33(15); V, 33(14); VI, 40(13); VII, 7; VIII, 10 microns. Length of spines at posterior angles of prothorax, 43–46 microns.

With a single spine on each posterior angle of prothorax; fore wings with spines as follows; fore vein 3–2–3, the latter three scattered in distal half of wing; hind vein with two spines in distal half.

Male allotype somewhat smaller, colored as in the female; with a pair of sickle-shaped spines on eight abdominal segment.

This species is closely related to S. *longipennis* Bagnall but may be separated by the following characters: the head is more transverse, the sixth antennal segment is longer than the third; spines on the posterior angles of the prothorax are longer and placed almost immediately on the angles; median spines on metanotum are placed away from the anterior margin. In *longipennis* the head is relatively longer, the third antennal segment is about as long as the sixth, the prominent spines on posterior angles of the prothorax are placed inward from the angles and the median pair of spines on the metanotum are placed immediately on the anterior margin. Also there are three scattered spines on distal half of fore vein of fore wing instead of two as in this new species.

Type material: female holotype and male allotype taken on tomato plants, June and July, 1931. (I. D. Dobrosky) (M. Nos. 5079 female, 4606 male).

Type locality: Manila, P. I.

Miss Dobrosky has forwarded a large number of specimens of thrips collected in the Philippine Islands and elsewhere and I take pleasure in naming this new species after her in recognition of her great interest in this group of insects.

Tribe ANAPHOTHRIPINI Priesner, 1926

ANAPHOTHRIPS (NEOPHYSOPUS) PIERCEI, sp. nov.

Female holotype: Head, antennal segments I, II and VI–VIII and abdominal segments seven to ten brown; prothorax brown but somewhat lighter than the head, pterothorax and first two abdominal segments light orange brown with meta-thorax darkened in front and at the sides; antennal segments III and IV, legs, and abdominal segments three to five clear yellow; wings clear to light yellowish, fore wings with a darkened cross band before the middle and another lighter brownish band before the end; terminal body spines dark brown.

Total length, .88 mm. Head length, .11 mm., width, .13 mm; prothorax length, .116 mm., width, .163 mm.; antennal segments length (width), III 36 (14); IV, 33 (15); V, 33 (15); VI, 43 (16); VII, 6; VIII, 10; total length 190 microns.

This species is typical of the genus, without prominent spines on head or thorax and with only a few scattered and very weak spines on both veins of forewings. It is closely related to A. *flavicinctus* Karny but distinguished by the coloring of the thorax and fore abdomen. *Flavicinctus* has a lighter colored prothorax and darker pterothorax and fore abdomen.

Type material: female holotype taken on "limba limba" grass, August 21, 1929, (W. D. Pierce). (No. 4286.)

Type locality: Bacolod, Occidental Negros, P. I.

I take pleasure in naming this species after the collector.

ANAPHOTHRIPS SACCHARI, sp. nov.

Female holotype: Color straw yellow including legs and most of antennae; tip of mouth cone, a spot on each tarsus and tip of abdomen blackish; first antennal segment clear, II darker than III–V which are like the body, (V clouded in distal half) VI–VIII brown with VI lighter at base; fore wings slightly grayish; crescents of ocelli deep orange.

Total length, .91 mm., head length, .73 mm., width, .117 mm., prothorax length, .117 mm., width, .147 mm.; antennal segments, III, 26; IV, 26; V, 26; VI, 36; VII, 6; VIII, 11 microns. Longest

spine on posterior angle of prothorax, 16 microns, on ninth abdominal segment 83 microns.

Head and prothorax without spines except a series of seven along posterior margin of prothorax, the outer one of which stands on the angle but is relatively short. The head and thorax are typical of the genus but the thorax is rather elongate, somewhat narrowed in front and widest in second third. Median spines on the metanotum placed well back from anterior margin. Fore vein of fore wing with 3–3 basal spines and 3 scattered in distal half; hind vein with 2 spines in distal half. Tip of abdomen pointed, longest spines on ninth segment reaching approximately to the end of the tenth segment; comb on ninth segment wanting.

Sacchari may be compared with *A. pannonicus* Priesner but this latter species is distinguished by having four spines on the hind vein of the fore wing and much longer spines on the ninth abdominal segment, 155–170 as compared with 83 microns in this new species. *A. sacchari* may also be compared with a species which I described as *Scirtothrips pomeroyi* from Gold Coast, East Africa. After a more careful study of *pomeroyi*, I have concluded that it too should be placed in the genus *Anaphothrips* and I am now designating it as such. *Pomeroyi* is without the darkened tenth abdominal segment, also it has four spines on hind vein of fore wing.

Type material: female holotype and two female paratypes taken in sugar cane flowers, November 22, 1929 (W. D. Pierce) (No. 4290).

Type locality: Victorias, Occidental Negros, P. I.

ANAPHOTHRIPS (CHAETANOPHOTHRIPS) AUREUS, sp. nov.

Female holotype: Head and body color including legs, clear lemon yellow with a black spot at tip of mouth cone and on each tarsus; antennal segments I–III and basal thirds of IV and V clear yellow, the rest of antenna dark brown; basal fifth of fore wing especially the scale, and a cross band near the middle dark brown, otherwise the fore wings are almost clear.

Total length, .95 mm. Head length, .083 mm., width, .123 mm.; antennal segments length (width), III, 36 (15); IV, 33 (16); V, 36 (15); VI, 40 (14); VII, 6; VIII, 12 microns. Pair of spines on each posterior angle of prothorax subequal, 40 microns.

Male allotype colored as in female; with an appendage at tip of abdomen bearing a pair of closely placed, curved, blackish brown spines, conspicuous because of their dark color.

This species differs from *orchidii* Moulton in its clearer body color and in the narrowed transverse band of fore wing, in *orchidii* this band extends to near tip of wing. Also in *orchidii* the sixth antennal segment is lighter in basal half while in *aureus* the sixth segment is uniformly dark brown.

Type material: female holotype, male allotype and one male paratype taken from tomato plants, June 10, 1931, (I. D. Dobrosky) (No. 4606.)

Type locality: Manila, P. I.

Subfamily THRIPINAE Karny, 1921

TAENIOTHRIPS CAVANALIAE Moulton, 1929.

One specimen (female) taken on a legume, October 20, 1931, in Laguna, P. I. (I. D. Dobrosky) (No. 5072).

TAENIOTHRIPS DISTALIS Karny, 1912.

One specimen, (female) taken on a legume, October 20, 1931, in Laguna, P. I. (I. D. Dobrosky) (No. 5073).

TAENIOTHRIPS VARICORNIS Moulton, 1928.

One specimen (female) taken on grass, June 22, 1931, at Los Baños, P. I. (I. D. Dobrosky) (No. 4663).

TAENIOTHRIPS LONGISTYLUS Karny, 1923.

One specimen taken from flowers of *Ricinus communis*, June 5, 1929, at Cadiz Viejo, Cadiz, Occidental Negros, P. I. (W. D. Pierce). One female and two male specimens taken on a legume, October 20, 1931, in Laguna (I. D. Dobrisky). Six females and two males taken on bean leaves at Laguna, Los Baños, in July and August, 1931. (D. T. Fullaway.)

TAENIOTHRIPS HAWAIIENSIS Morgan, 1913.

Numerous specimens taken on *Solanum* sp., April 26, 1928, at Saravia, Occidental Negros, P. I. (W. D. Pierce) (No. 4245).

TAENIOTHRIPS PECULIARIS Bagnall, 1918.

One male specimen taken on a legume, October 20, 1931, in Laguna, P. I. (I. D. Dobrosky) (No. 5067).

TAENIOTHRIPS ALLIA, sp. nov.

Female holotype: Head and body uniformly dark brown; all antennal segments dark brown except III which is yellowish

brown; fore femora dark brown, fore tibiae brownish yellow, all tarsi yellow; middle and hind tibiae dark brown, yellowish at the joints; wings almost clear, with only shading of brownish yellow.

Total body length, 1.35 mm. Head length, .14 mm., width, .15 mm.; antennal segments length (width), III, 46 (22); IV, 46 (22); V, 50 (22); VI, 40 (18); VII, 10; VIII, 10 microns. Interocellar spines 16, outer on posterior angles of prothorax, 43, inner, 50–63, on posterior angles of ninth abdominal segment, 120, at tip of tenth, 116 microns.

This species is characterized by its rather short interocellar spines which are placed outside of the ocellar triangle, on either side of or slightly back of the anterior ocellus; by the subequal segments of the style; by a series of four spines on either side along the posterior margin of the prothorax, the third in each series being longer than the others, also the median pair of spines on the metanotum are placed away from the anterior margin.

The fore vein of the fore wing has a basal series of 7 spines and 2 at tip, hind vein with 10–11 spines. The comb on eighth abdominal segment is wanting. The terminal segment has an almost complete dorsal suture.

This species may be compared with *frontalis* Uzel but is easily separated by its darkened middle and hind tibiae, in *frontalis* all tibiae and tarsi are lemon yellow. *Ericiola* Bagnall, another closely related species, is separated by its orange yellow color and yellow legs.

Type material: female holotype taken from onion blossoms, May 27, 1931, (I. D. Dobrosky) (M. No. 5078.)

Type locality: Manila, P. I.

TAENIOTHRIPS PULCHELLA, sp. nov.

Female holotype: Predominating color yellow including all legs; pterothorax with orange pigmentation, and showing faint clouding of brown at the sides; abdomen with two longitudinal brown stripes extending from third to seventh segments, the same segments with transverse cloudings of brown on the tergites. Antennal segments I and II brown, III clear in basal two-thirds, shaded with brown in distal third, IV clear in basal half, brown in distal half, V clear in basal half shaded in distal half, VI–VIII brown. Fore wings brown at base and with two brown cross bands, one in the middle and another before the end, white cross bands between the brown ones, clear at tip.

Total body length, .8 mm. Antennal segments length (width): III, 50 (20); IV, 53 (16); V, 40 (13); VI, 50, VII, 10; VIII, 16 microns. Interocellar spines, 26, outer at posterior angles of prothorax, 36, inner, 40 microns.

Unfortunately this beautiful little thrips is mounted on the side so that it is impossible to describe it with greater accuracy. The third and fourth antennal segments are distinctly constricted neck-like before the ends. The fore vein of the fore wing has two groups of 3–3 spines at base and 2 near the extreme tip, hind vein 13 spines.

This species may be compared with *T. xanthius* Williams but immediately distinguished by the distinct banding of the fore wings.

Type material: female holotype, taken on cotton, *Gossypium brasiliense,* July 16, 1928 (W. D. Pierce).

Type locality: Victorias, Occidental Negros, P. I.

FRANKLINIELIA INSULARIS Franklin.

One female specimen taken from flowers of *Stachytarpheta jamaicensis* June 7, 1927 (W. D. Pierce). Unfortunately, the single specimen is distorted and the antenna lost so that the identification as to species is not certain.

THRIPS ALBIPES Bagnall, 1914.

Collections taken from mango flowers, January 8, 1935 (F. Q. Otanes), at Singalong, Manila (Bureau of Plant Industry No. 4054); on "Quigar" at Concepcion, Cadiz, Negros, May 16, 1928 (W. D. Pierce), (Moulton No. 4248); in flowers of *Carica papaya,* May 18, 1928 (W. D. Pierce) (No. 4250); on *Lantana camara,* Sta. Isabel, Victorias, Negros, Sept. 11, 1928 (W. D. P.) (No. 4251); in banana flowers, October 25, 1929; from roses and corn, Los Baños, September 9, 1931 (I. D. Dobrosky) (No. 4136).

THRIPS PALLIPES Bagnall, 1926.

Specimens taken from Gardenia flowers, July 15, 1931, Los Baños, (I. D. Dobrosky) (No. 4659); tangerine, May 28, 1931, Batangas (I. D. D.) (No. 5066); native orange blossoms at Alabang, May 28, 1931, (I. D. D.) (No. 4669); on a legume, October 20, 1931, (I. D. D.) (No. 4136).

THRIPS CLARUS Moulton, 1928.

Several specimens taken in flowers of *Stachytarpheta jamaciensis,* June 7, 1929, at Sta. Margarita, Saravia, Occidental Negros, (W. D. Pierce); a number of males taken in flowers

of "Quigar," May 16, 1928, at Concepcion, Cadiz, Occidental Negros (W. D. Pierce) (No. 4265). These specimens are assigned to this species with uncertainty because of their mutilated condition.

THRIPS VICTORIENSIS, sp. nov.

Female holotype: Color pale yellow including head, thorax, first seven abdominal segments, legs, first three antennal segments and basal half of IV, V, and VI; distal half of each of IV, V, and VI abruptly brown to dark brown; ninth and tenth abdominal segments and most of eighth abruptly blackish brown; fore wings clouded gray, lighter before the tip; prominent body and wing spines clear to light brown, only long terminal spines blackish brown.

Total length, .89 mm.; head length, .10 mm.; width, .126 mm.; antennal segments length (width) III, 46(16); IV, 40(16); V, 33(15); VI, 46; VII, 16 microns. Length of prominent spines, postoculars, 43, on posterior angles of prothorax, subequal, 53; on ninth abdominal segment, 123, on tenth segment, 83 microns.

Head broadly rounded in front, cheeks slightly arched; setae in front of and behind eyes, and ocelli moderately long, one especially long immediately behind eyes; setae on thorax also rather long, approximately 26 microns, three on either side along posterior margin; two pairs of setae on metanotum arranged in a semicircle, the median pair placed away from the anterior margin. Fore vein of fore wing with 3–3 basal spines, one wing with 2 and the other wing with 3 distal spines; hind vein with 10 spines; all of these rather long, approximating middle width of wing. Spines on ninth abdominal segment much longer than those on the tenth. Comb on eighth abdominal segment complete.

T. victoriensis may be compared with *T. japonicus* Bagnall but is easily separated by the color of antenna and abdomen.

Type material: female holotype taken at Victorias, Occidental Negros, P. I. (W. D. Pierce) (No. 4295).

THRIPS TUSCA, sp. nov.

Color, head and body uniformly dark brown, antenna dark brown except segment III which is yellowish brown and IV which is of a lighter shade than the others; legs mostly dark brown, yellowish at the joints and with all tarsi and tips of all tibiae yellow; wings uniformly brown.

Total length female 1.17 mm. Antennal segments length III, 36; IV, 36; V, 33; VI, 46; VII, 16 microns. Length of spines, on posterior angles of prothorax, outer 60, inner 66 microns; on ninth abdominal segment 106, on tenth segment 96 microns.

Head broader than long, clearly rounded in front, head setae distinctly shorter than in *victoriensis*, cheeks almost straight; with three spines on either side along posterior margin of prothorax; median spines on metanotum placed approximately 16 microns back from anterior margin and about the same distance apart. Fore vein of fore wing with 3–3 basal spines and 2 near the tip, hind vein with 12 spines. Comb on eighth abdominal segment complete.

This species may be compared with *griseus* Bagnall but separated by its more uniformly brown colored antenna, except the third segment, the yellowish joints and tips of middle and hind tibiae, and the 2 distal spines on fore vein of fore wing. *Fusca* also approaches *herricki* Bagnall in general color but is again separated by the color of the antenna and the number of distal spines on fore vein of fore wing.

Male: similar in color but smaller.

Type material: This species is described from three female cotypes and one male taken on seedling sugar cane, February 5, 1927, (W. D. Pierce) (No. 4241).

Type locality: Victorias, Occidental Negros, P. I.

THRIPS ARMATA, sp. nov.

Female holotype: Color yellowish brown with forehead darkened; first antennal segment brown, II–V and basal half of VI clear yellow, with II somewhat clouded, distal half of VI and VII blackish brown; all legs yellow with femora shaded brown on upper margins; wings clear in basal fifth, otherwise washed with brown; cresent of ocelli deep orange red.

Total length, 1.1 mm.; head length, .13 mm.; width, .147 mm.; prothorax length .14 mm.; width .17 mm.; antennal segments length (width) II, 30 (25); III, 36 (18); IV, 36 (18); V, 32 (16); VI, 50 (16); VII, 20 microns; length of spines: anteocular 50, pair on posterior angles of prothorax, outer 43, inner 50; longest on ninth abdominal segment 126, on tenth 110 microns.

Head slightly wider than long, angular in front, cheeks nearly straight, with a strongly developed spine near anterior margin, in front of each eye; setae in front of ocelli and behind eyes very small; antennal segments III and IV of equal length.

Prothorax with a pair of strong spines on each posterior angle, three on either side along posterior margin, these thin and weak, the inner pair longest; setae on pronotum weak and sparce. Median spines on metanotum placed back from anterior margin but close to and almost immediately behind the smaller outer pair which are near the margin. Fore vein of the fore wing 3–3 basal spines and 3 almost equally placed distal spines, hind vein with 12 spines.

Abdominal segments two to eight with well developed saw-toothed edges on posterior margins of pleurites, these also developed on the tergites at the sides. These saw-toothed projections more weakly and irregularly developed on the sternites. Comb on posterior margin of eighth abdominal segment wanting.

Male allotype colored as in female but with forehead and distal half of abdomen distinctly darker and pro and mesothoraces noticeably more yellowish. Sternites three to seven with transverse depressions occupying median third; sternites three to nine with strong, regularly placed, long and pointed projections along posterior margins. Total length, .926 mm.

Type material: female holotype, male allotype, seven female and three male paratypes taken on citrus seedlings and on sugar cane on various dates in 1927–1929 (W. D. Pierce) (Nos. 4239, 4242, 4249).

Type locality: Victorias, Occidental Negros, P. I.

I have described this as a new species with some hesitancy at it may be "*Thrips serratus*" Kobus and yet there are characters as mentioned by Dr. H. H. Karnay which would seem to set *Thrips serratus* apart as another species and possibly belonging also in another genus. Otherwise, *T. armatus* is most closely related to *T. saccharoni* Moulton. This latter species, however, has the distal third of the fifth antennal segment brown, in this new species the fifth segment is entirely clear yellow.

MICROCEPHALOTHRIPS ABDOMINALIS Crawford, L (L).

Many specimens taken on various plants in April and May, 1929, at Victorias, Occidental Negros (W. D. Pierce).

ISONEUROTHRIPS ROSACEAE, sp. nov.

Female holotype: Color chestnut brown, legs yellow, with a shading of brown on outer margins of all femora; antenna brown, with segment III yellowish, IV and V yellowish at base; fore wings uniformly brown; prominent body spines dark brown; abdominal segments two to eight each with a dark

brown transverse line near anterior margin; crescents of ocelli orange red.

Total length, 1.17 mm.; head length, .088 mm.; width, .14 mm.; prothorax length .117 mm., width .176 mm.; antennal segments length (width) III, 40(18); IV, 40(18); V, 30(15); VI, 40; VII, 10 microns. Length of spines: interocellar and postoculars, about 13 microns, pair on posterior angles of prothorax about equal, 60, longest on ninth abdominal segment, 90, on tenth, 83 microns.

Male allotype: Colored as in female; smaller; with transverse ventral depressions which extend almost across sternites two to seven.

This species is characterized by the very small interocellar and postocular setae and the absence of any conspicuous interocellar or postocular spines. There are three spines on either side along posterior margin of prothorax, the inner pair being longest. Median spines on metanotum are placed well back from anterior margin. The fore vein of fore wing has a series of about 20 regularly placed spines, hind vein with 17. Comb on eighth abdominal segment is completely wanting.

Rosaceae may be separated from *multispinus* Bagnall by the small head setae instead of larger spines as in the latter species.

Type material: female holotype taken from a rose, July 9, 1931, (No. 4664); one female paratype from Gardenia flowers, July 15, 1931, (No. 4659) (I. D. Dobrosky); male allotype taken June 5, 1929, (W. D. Pierce) (No. 5001).

Type locality: Los Baños, Laguna, P. I.

The New Under-Secretary of Agriculture and Commerce

JOSE S. CAMUS

(See biographical sketch on p. 275)

QUARTERLY NOTES

PERSONAL GLIMPSE OF OUR NEW UNDER-SECRETARY

The appointment of Mr. Jose S. Camus to the office of Under-Secretary of Agriculture and Commerce has bolstered up the morale of the personnel of the Department of Agriculture and Commerce; for Mr. Camus has risen from the ranks through sheer hard toil and merit. The promotion of a man who started from the lowest rung of the ladder and forged ahead step by step to the highest position that a technical man can aspire in a Government department, will serve, for those who are still serving in more or less humble capacities, as a strong motivating power for greater effort and greater service to the people. It will make every official or employee feel that he is a potential candidate for the office on the level immediately above his; this, naturally, will mean greater efficiency of the service.

Under-Secretary Camus was born on January 12, 1892, in Malabon, Rizal. He came from a family that lived according to the principle that only education clothes a man with dignity in the social order of things. Mr. Camus' family cherished a promising future for him and spared no cost to send young José to school. After finishing his grade school in his hometown, he attended Ateneo de Manila, Philippine Normal School, and the Junior College of Liberal Arts, University of the Philippines.

But his highest aim in life was to become an agriculturist—a vocation which had no glittering charm to the common run of youths of those days. He enrolled in the College of Agriculture, University of the Philippines, and plodded his way painstakingly to finish a good task.

He was graduated from the college in 1914; and bearing the escutcheon of a full-fledged agriculturist, he started to apply the knowledge he acquired by getting a job as a soil chemist with Behn, Meyer and Company, taking charge of the Fertilizer Department of the Company's branch in Iloilo.

Later he was drafted into the Government service. On July 30, 1914, he was named agricultural assistant in the former Bureau of Agriculture. After he had passed the assistant agronomist examination given by the Bureau of Civil Service on

September 6, 1915, his promotion in the Government was steady, to wit: He was promoted to the position of agricultural inspector, November 9, 1918; to that of supervising inspector of rice and corn stations, February 1, 1920; and to that of agronomist, February 1, 1921.

In 1922 a reshuffling of the staff and personnel of the Bureau of Agriculture was effected, and Mr. Camus, in view of his brilliant record in the past as a fieldman and specialist in rice culture, was picked for the position of assistant chief, Agricultural Extension Division. The following year, May 16, 1923, to be exact, he was appointed chief of the division.

About this time the Bureau of Agriculture had grown in size, personnel, and appropriations (₱2,000,000) so that the need for an effective supervision over its diverse activities in the field was felt. As a result the position of inspector-at-large was created, a position third in importance in the official hierarchy of the Bureau of Agriculture. The logical man for the position was Mr. Camus, and was made inspector-at-large, April 18, 1925.

When the late Silverio Apostol, then Assistant Director of Agriculture, was named Under-Secretary of Agriculture and Natural Resources, Mr. Camus had already built up a reputation as an executive, and the choice for Assistant Director fell on him on November 18, 1927.

On May 3, 1928, Dr. Stanton Youngberg, Director of Agriculture, went on leave to his home country, the United States, and Mr. Camus was made Acting Director, holding the reign of the administration of the Bureau for almost a year.

By legislative act the Bureau of Agriculture was divided into the Bureau of Plant Industry and the Bureau of Animal Industry. Mr. Camus was the logical man to become Director of the newly created Bureau, but, instead, he was made Assistant Director. But one can not keep a good man down permanently. It was not very long when justice was done to him. On August 20, 1934, he was promoted Director of the Bureau.

During his incumbency as Director of Plant Industry he introduced a number of changes and innovations in his Bureau, that increased the efficiency of the services which the Bureau of Plant Industry is rendering the public. The sound judgment he showed on these occasions, together with his being a hard worker and his thorough knowledge of the pressing agricultural problems confronting the Commonwealth, impressed his chiefs, and he was selected for the office of Under-Secretary of Agriculture and Commerce, which he assumed June 6, 1936.

Aside from the technical positions he has held in the Government, he rendered service in other phases of government activity designed for agricultural and scientific investigation and research. He was named Chairman, Rural Improvement Committee, created by Governor-General Murphy; member, Educational Survey Committee; member, Tobacco Board; member, Irrigation Council; Chairman, Sub-Committee on Agricultural Education, National Survey Committee; Charter Member, National Research Council of the Philippines; Chairman, Division of Agriculture and Forestry, National Research Council of the Philippines; member, Committee of Directors as provided under section 1 of the Colonization Law, Act No. 4197; member, National Emergency Relief Board; member, Committee on Food Raising, National Emergency Relief Board; Chairman, Rice Nationalization Committee; Vice-Chairman, Committee on Soil Survey; Vice-Chairman, Trade Relation Committee; member, Committee on San Lazaro Investment and Friar Lands Loan Fund; member, Committee to gather data on Friar Lands and other Estates; member, Department Committee to assist the Committee of the Constitutional Convention on the Nationalization and Conservation of Lands and Natural Resources; member, Committee on Vocational Survey in the Philippines; and member, Committee created for the study of giving homesteads to agricultural graduates.

Mr. Camus is a widely-travelled man. As one of the delegates to the Panama-Pacific International Exposition in San Francisco, California, he visited that country in 1915. He was also a member of the Philippine delegation to the International Agricultural Conference and Exposition in London, 1921; member of the Philippine delegation to the 4th Pan-Pacific Science Congress in Java, in 1929. During his trips abroad he visited and studied agricultural conditions in Ceylon, Egypt, Spain, France, Belgium, and England. He worked in the offices of the Department of Agriculture in Washington, D. C., and important agricultural stations and colleges in the United States. He was also sent by our Government to Sumatra, Straits Settlements, Siam, and Indo-China to make a survey of the agricultural conditions in those countries.

At present he is an active member of the Philippine Economic Association, Philippine Scientific Society, Philippine Columbian Association, Pan-Pacific Association, and the College of Agriculture Alumni Association, which he served for some time as president.

Under-Secretary Camus has written extensively on the culture of corn, rice, cassava, palay, rubber, and on coöperative marketing as a factor in improving our agricultural conditions. He is the best authority on Philippine rice, a subject on which he has written a treatise.

The records and achievements of our present Under-Secretary will impress anyone that he is a really prolific agriculturist. He conscientiously planted honest labor into the soil of public service and he has reaped the fruit. His promotion to his present post is lauded as propitiously timely and wise. The technical training and experience of Mr. Camus, matched with the assiduousness and efficiency he always registers, will help in a large measure the solution of the pressing economic problems which face not only the Department of Agriculture and Commerce but the whole country. The pride of a command in one of the most important executive departments of the government is his. His subordinates will profit by it. We know well enough our present Under-Secretary to feel confident that he will do his job well.

THE NEW DIRECTOR OF PLANT INDUSTRY

When Hilarion Silayan was appointed Director of Plant Industry on June 6, 1936, there was added to the executive force of the insular administration a man who, through meritorious service and exceptional aptitudes, has risen from the ranks. It is timely and opportune that a man of his achievements and qualifications occupy a post that calls for greater technical ability, especially when the nation is in great need of men trained by experience along economic lines, particularly along agricultural and industrial lines.

Director Silayan was born in Binañgonan, Rizal, October 21, 1894. His parents being poor, young Hilarion learned in early childhood that no greater thing than education would help him rise up in the scale of the social structure. It was constant awareness of the limitations of poverty that created in him a determination to be somebody in the future, and prompted him to utmost effort in acquiring an education.

He started to become a lawyer, for the glamour surrounding the legal profession, which makes the members of the Bar easily climb socially and politically, attracted him. But he soon realized that to become a lawyer one needs plenty of money because of the prohibitive matriculation fees and costly law books. So he turned to a course in which money is not so much needed, as brains and brawn: the agricultural course. What the legal profession had lost is a gain to the agricultural field. Thus, after many years of hardship and sacrifice, he was among the graduates of 1917 from the College of Agriculture, University of the Philippines.

No sooner had young Silayan left the portals of his Alma Mater, with his Bachelor of Science in Agriculture diploma tucked under his arm, than the position of deputy governor of Lanao was offered him by the then Secretary of the Department of Mindanao and Sulu, Governor Carpenter. Scoffing at the discouraging attitude of his friends and associates, he accepted the offer without hesitation. Although Silayan was but 22 years old at that time, and fresh from college, what he lacked in wordly experience he made up in a degree of alertness and courage that would do honor to more mature men. With

his technical knowledge in the science of agriculture, he was instrumental in the development of coconut orchards and abacá plantations in Moroland. He also was able to maintain close friendship with the Moros, who, during those days, were considered still very primitive and warlike. This friendly relationship enabled him to convince them of the advantage and practicability of planting coffee, bananas, and corn.

The position of deputy governor of Lanao he held from March 1917 to March 1920, when Dr. E. B. Copeland, who owned rice ranches in Chico, California, offered him a position as farm manager of the said ranches. He stayed on these plantations for three years (April 1920 to April 1923). When his contract with Dr. Copeland expired, he enrolled in the College of Agriculture, University of California, obtaining his Master of Science degree in Rural Economics, 1924.

Soon after graduation from that College, he was employed with the Dupont Carleton Mills, San Francisco, California. He worked there from January 1925 to March 1925, when he was offered a contract as agriculturist for the Insular Irrigation System, Bureau.of Public Works, of the Philippine Government. Due to his desire for further exploits in the United States, and his still unsatisfied zest for adventure in foreign lands, Mr. Silayan was at first reluctant to accept the offer. But the call of his country prevailed, and he embarked for home on the first available transport. His contract with the Bureau of Public Works lasted from July 1925, to March 1929. In April 1929 he was placed in charge of the new project of seed farms, of the Bureau of Agriculture, which position he held until December 1929.

When the Bureau of Plant Industry was created out of the erstwhile Bureau of Agriculture, and a consequent overhauling of the office organization was effected, he was appointed, January 1930, Chief, Agricultural Extension Division, Bureau of Plant Industry, which position he held until his appointment as Director of Plant Industry.

Capabilities and aptitudes that are not ephemeral always locate their proper place. This has been manifested in the case of the newly-appointed Director of Plant Industry. Aside from his regular duties in the Government service, he had served in several capacities under various branches of the Insular Government, among which are: Member, Investigation Committee on Insular Irrigation System, 1929–1930; Organizer and First Sec-

The New Director of Plant Industry

HILARION S. SILAYAN

retary, National Rice Growers Association, 1931; Member and Executive Officer, Rural Improvement Committee, 1933–34; Charter Member, National Research Council, Member, Philippine Economic Association, Member, Philippine Scientific Society, 1934; detailed to the Department of Labor to organize land settlements in Mindanao, 1935; in charge of Fact-Finding Survey on Rural Conditions under the Department of Labor, 1936. Besides these numerous activities, he has served as Executive Officer of the horticultural shows and agricultural, commercial, and industrial expositions of the Department of Agriculture and Commerce during the Manila carnivals (1932–1935).

Director Silayan has qualified in all Civil Service examinations given pertaining to his particular attainments and qualifications, as follows: Scientific assistant, 1917; assistant agronomist, 1918; agricultural inspector, given by the United States Civil Service Commissioner for services in the Possessions, 1925.

With his special knowledge in rural institution, agricultural extension work, farm management and marketing of farm products, economics and business administration, and history of agriculture, which he had mastered during his studies in the University of California, together with his research work in colony administration, Director Silayan is well equipped to carry out his projected aims announced by him immediately upon assuming his office, among which are: humanization of agriculture, diversification of crops, amelioration of the lot of the small farmers; improvement of rural conditions; planting of idle sugar cane and rice lands with various short-season crops; planting of fruit trees by farmers; and the promotion of coöperative effort among copra producers and coconut growers. Besides his plan of bringing the Plant Industry Bureau closer to the farmers, he is at the same time readjusting the internal organization of his Bureau with a view to attaining utmost economy, and promoting greater efficiency and the maintenance of good morale among the personnel of the various branches of his Office.

Moderately aggressive with tangible principles and ideals that find expression not merely in platitudinous concepts, Director Silayan has always the interests and welfare of the poor at heart. Not imbued with too much self-importance, Mr. Silayan, whose capable mind rests in a very sound and robust body, is the very man to help uproot unsound radical ideas from among the farming masses, attitudes that are slowly poisoning the minds of the ignorant farmers, and consequently hinder the rapid agricultural progress of the Commonwealth.

INTRODUCTION OF THE GIANT TOAD, *BUFO MARINUS*, INTO THE PHILIPPINES

By Gonzalo Merino

Chief, Plant Pest and Disease Control

The Giant Toad, *Bufo marinus*, was introduced in the Philippines barely two years ago. On my way to the Philippines from the United States during the spring of 1934, I visited Hawaii. There I was shown by Messrs. Swezey and Van Swaluewenburg, entomologists of the Hawaiian Sugar Planters Association, some voracious toads which they had in confinement. While we were watching the toads a large number of Sphinx moth larvæ was introduced, and in a short time, the toads devoured them.

This toad, *Bufo marinus*, is a native of the tropics. Because of its insectivorous habit, it has been introduced into the different parts of the South American Continent and the West Indies. According to Pemberton,[1] it is known to occur from Mexico to North Argentine, including the Island of Trinidad. It was introduced in Bermuda and Barbados from Brazil. In Porto Rico this toad was introduced from Barbados and later on from Jamaica. According to the same information, the toad increased so rapidly that it is now widespread in Porto Rico. It is stated that in that part of the island where distribution of this amphibian is heavy, the farmers reported decreased depredations of mole cricket and white grubs. In Hawaii where it was introduced by Pembreton in March and April, 1932, from Porto Rico, through the North American Continent in four separate lots, the toad is multiplying in great numbers, and the Hawaiian Sugar Planters Association is distributing them in the fields.

The liberations of this toads in Hawaii were done during the last half of April, 1932, on the upper Manoa Valley and Waipio, on the Island of Oahu. In August of the same year, several young toads were seen at Waipio.

[1] Pemberton, C. E. 1933. Introduction to Hawaii of Tropical American Toad, *Bufo marinus.*, Haw. Planters Record, Vol. 35, No. 1, pp. 15–16.

When I visited the Island of Oahu, there were so numerous of this toad that the entomologist of the Hawaiian Sugar Planters Association were moving them in great quantities and liberating them near reservoirs and ponds to breed and spread into the adjacent agricultural land.

I brought 28 of them home to the Philippines, thru the courtesy of the Hawaiian Sugar Planters Association. The amphibians were packed in a wooden box with thoroughly moistened wood shavings. No food was introduced, but the container was kept moist in a cool place. After a trip of 19 days, only two died on the way. The toads are now kept in a wire confinement made for the purpose with an improvised pool of water. During the time of confinement, four were able to escape and one died. The remaining 21 are still in confinement where they are kept for breeding purposes.

The toad was introduced in Puerto Rico from Barbados in 1920, and from Jamaica in the year 1924 [2] by the Federal Agricultural Experiment Station at Mayaguez to prey upon major pests, such as June beetles, mole crickets and cocroaches. According to the latest report of Walcott,[3] the white grubs, which were considered major pests, are now so few in Puerto Rico that they are no longer considered economic pests.

DESCRIPTION AND HABIT

The Giant Toad is so-called because it is the largest toad known. It is reported by Leonard to attain as much size as 9 inches from the snout to the vent. The female is larger than the male. The color is that of dark brownish on the upper part. The legs are dingy yellowish-white. The males are lighter in color.

The toad is nocturnal in habit. In the day time, it stays quite in some sheltered places, generally, under some moist stones or in the water. This is especially true during hot days. They venture to come out only when forced by hunger, and this is generally done after a rain. This habit is due to the excess evaporation that the animal suffers, the skin being quite porous. It is through the skin that the animal takes in water.

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[2] Leonard, M. D. 1933. Notes on the Giant Toad, Bufo Marinus, in Puerto Rico, Jour. Econ. Entom. Vol. 26, No. 1, pp. 67–71.

[3] Wolcott, G. U. 1935. Report of the Director for the year 1933–1934. Agrc. Expt. Sta. Puerto Rico, p. 142.

The animal eats only living organisms—moving insects like earthworms, centipedes and millipeds. It is able to catch insects in actual flight. The tongue is the only organ for taking its food. Whenever this animal catches worms, which are big in size, the fore limbs are used to help force the captured animal into its gullet. As it is stated, the animal being norturnal in habit, goes out regularly at night to catch insects. The food has been observed to be from 95 to 98 per cent animal matter, consisting of earthworms, centipedes, millipeds, Arachnids, Isopods; the greater part consisting of insects. In so doing, the toad is considered one of the beneficial animals and should be protected. It is true that it may take in some beneficial insects such as Carabid beetles, ladybird beetles and some hymenopterous parasites; but for the most part it eats more injurious insects.

CARE OF THE TOAD

The animal is supposed to be sexually matured in 4 years and after that time reproduction begins. More than a thousand eggs are laid at one time in the water or in some places near the water. Shortly after mating, slimy "rope" of eggs are laid. After a week or so, little tadpoles fall into the water and feed on some little water organisms, such as infusuria, rotifers and even wrigglers of mosquitoes. They can be fed artificially by means of corn mass or oatmeal. When propagating toads, care should be taken in having a pond in the enclosure whereby the toads could get in for the water needed, and that stone chambers be placed in such a way that the toads may have place to shelter during the heat of the day. After a lapse of time, the tadpole develops its hind legs and then fore legs. At this time, they breath through the lung and jump out from the water and start feeding on insects. When they reach the size of a "peseta," the little toad can be distributed in the field, preferably near reservoirs or ponds where they may go for water requirements, or multiply should they reach maturity.

It is hoped that the toads that we have here in confinement may be able to multiply soon. If the people wish to have these toads in their gardens or plantations, they can import them direct from Hawaii where they can be gotten in quite fair numbers.

POSSIBLE NATURAL ENEMIES OF THE TOADS

Crows and hawks have been known to be their worse enemies. It has also been known that owls and snakes are enemies of this animal, and probably lizards too. But the worst enemies that may be mentioned are children who toy with them. Inasmuch as they are beneficial, protection should be given to these toads. Legislations should be enacted protecting these toads just like birds.

ILLUSTRATION

PLATE 1. The giant toad, *Bufo marinus.*

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PLATE 1. THE GIANT TOAD, Bufo marinus